PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

On the Cranial and Facial Characters of the Neandertal Race

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Phil. Trans. R. Soc. Lond. B 1908 **199**, 281-339
doi: 10.1098/rstb.1908.0007

VII. *On the Cranial and Facial Characters of the Neandertal Race.*

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(Received May 15,—Read November 14, 1907.)

[Plate 29.]

So long as the Neandertal skull was the only known example of its kind, the precise value of the evidence it affords as to the history of the human race was open to question, since among the hordes of primitive men who occupied the soil of Europe in early palæolithic times there were probably many individuals distinguished by characters more or less out of the common, and to one of these exceptions the Neandertal skull might by some odd chance have belonged.

Now, however, since our knowledge has been enlarged by the discovery of similar skulls or fragments of skulls at Spy, Krapina, and elsewhere, the Neandertal calvarium no longer stands alone, and we are at present in possession of sufficient material to pursue our investigations into these oldest of human remains with the confident assurance that we have to do, not with extreme forms or exceptional sports, but with fairly average examples of a once existent race. Under the stimulus of renewed interest awakened in consequence, the Neandertal skull, and others related to it, have been made the subject of fresh studies, of which the elaborate memoirs of Schwalbe are the first fruits.*

It is interesting at the outset to observe how closely these latest researches have followed the lines first laid down by Huxley; the massive brow ridges, low calottal height and short sagittal suture, the retreating forehead and occiput, which the great anatomist singled out as the most distinctive features of the Neandertal skull, stamping it as the most ape-like he had ever beheld, are likewise those on which Schwalbe lays greatest stress, while endeavouring to define them more precisely by additional measurements.†

In their final judgment, however, touching the degree of relationship which exists between the Neandertal skull on the one hand and the skulls of recent races on the other, these two authorities differ widely. Huxley's opinion is best expressed

* G. Schwalbe, "Studien über *Pithecanthropus erectus*," 'Zeitschr. f. Morph. u. Anthropol.,' vol. 1, pp. 16–240, 1890; "Der Neandertalschädel," 'Bonner Jahrbücher,' part 106, 1901; "Über die specifischen Merkmale des Neandertalschädels," 'Verhandlungen der anatom. Gesellsch.' 15 Versammlung in Bonn, pp. 44–61, 1901; 'Die Vorgeschichte des Menschen,' Braunschweig, 1904; "Studien zur Vorgeschichte des Menschen," 'Zeitschr. f. Morph. u. Anthrop.,' Sonderheft, 1906.

† Huxley in Lyell's 'Antiquity of Man,' London, 1863, pp. 80–89, and 'Man's Place in Nature,' London, 1864, pp. 128–159.

in his own words; after emphasising the high cranial capacity of the Neandertal skull, he adds: "In no sense then can the Neandertal bones be regarded as the remains of a human being intermediate between Men and Apes. At most they demonstrate the existence of a Man whose skull may be said to revert somewhat towards the pithecoid type . . . And, indeed, though truly the most pithecoid of known human skulls, the Neandertal cranium is by no means so isolated as it appears to be at first, but forms in reality the extreme term of a series leading gradually from it to the highest and best developed of human crania. On the one hand it is most closely approached by the flattened Australian skulls . . . from which other Australian forms lead us gradually up to skulls having very much the type of the Engis cranium . . . " and, again, "in conclusion, I may say that the fossil remains of Man hitherto discovered do not seem to me to take us appreciably nearer to that lower pithecoid form, by the modification of which he has probably become what he is."

This expression of opinion I believe to have been a strictly logical inference from the facts as they were known at the time.

Professor SCHWALBE, whose conclusions we are about to examine in detail, considers that the characters of the Neandertal calotte indicate a race so far removed from all existing varieties of mankind as to be entitled to the rank of a distinct species, for which he adopts the name of *Homo primigenius*, Auct. Controversies as to the validity of species are at present somewhat out of date, so that when HÆCKEL subdivides the human race into a number of such groups, no one feels called upon to offer any earnest remonstrance. Professor SCHWALBE, however, although he nowhere informs us of the sense in which he employs the term, evidently takes species more seriously, and by his proceeding we are called upon to admit that the Neandertal differed from existing races to a greater degree than these differ among themselves. This is a proposition of no trifling importance, and well worthy of the careful consideration we propose to give to it. If in some important respects my results should be found to differ from those of Professor SCHWALBE, this is to be attributed in great part to the advantage I have enjoyed of access to the fine collection of Australian skulls in our University Museum; it numbers in all some 50 specimens, of which 12 are from South Australia.

Our first proceeding will be to compare, according to the methods introduced by Professor SCHWALBE, the calvaria of the Neandertal group with that of a South Australian aborigine. The Australian skull which we select for this purpose bears the number 998 in our collection, and is recorded as having been picked up from some "reed beds" about five miles out of Adelaide; it is that of an adult male, and extremely dolichocephalic, with an index of 66·04.

One of the most important, as it is certainly one of the most striking, peculiarities of the Neandertal calotte is the frontal torus, *i.e.*, the confluent supra-orbital tori; this is distinguished not merely by its magnitude, though this is excessive, but still more, as SCHWALBE points out, by the continuous and uniform character which it maintains throughout its whole extent. In the skulls of Australian natives two regions may usually, though not always, be distinguished in each supra-orbital torus, a more or less shallow groove which takes an oblique course, separating an outer temporal from a more median supra-ciliary region; in the Neandertal group this groove is almost, if not entirely, effaced.

In the Australian skull under consideration, the frontal torus (*oγν*, fig. 1) is less

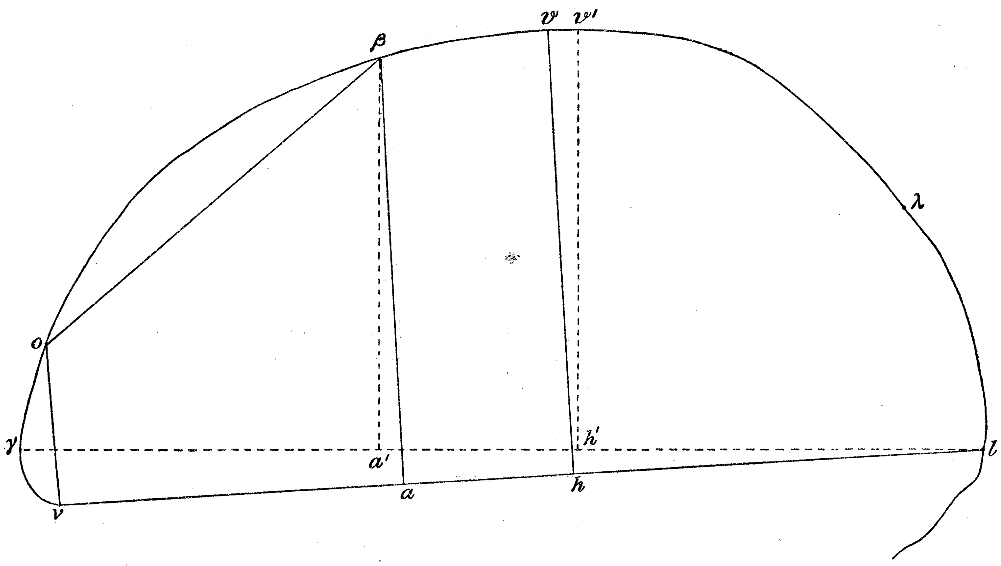

FIG. 1.—Median curve of a South Australian skull (No. 998); *a*, projection of the bregma on the nasi-inion line; *a′*, on the glabella-inion line; *vh*, height measured from the nasi-inion line; *v′h′*, from the glabella-inion line. $(\times \frac{2}{3}.)$ For explanation of the other symbols, see footnote, p. 284.

marked than in some others of our collection, but its index is not so low as at first glance we might expect. The glabellar index, as defined by SCHWALBE, depends on the position of the ophryon, the determination of which, as TOPINARD points out, is certainly difficult. According to BROCA, it lies on the intersection of the median line of the skull and a transverse line drawn from the most closely approximated points of the temporal ridges. TOPINARD, however, proposes to identify it with the inter-supraciliary point, which is determined by the intersection of the median line and the shortest superficial curve tangential to the posterior margin of the brow ridges. In our Australian skull the ophryon and the inter-supraciliary point are, as a matter of fact, coincident, lying 30 millims. from the nasion, as measured in a direct line, and 96 millims. from the bregma; the glabellar index is, therefore, 31·25 ($30 \times 100/96 = 31{\cdot}25$).

The highest glabellar index which I have so far encountered among Australian skulls has a value of 39·76; it occurs in a specimen, numbered 976, from Queensland, the nasi-ophryon line of which is 33 millims., the ophryo-bregma chord only 83 millims. in length. In another remarkable skull, also from Queensland (No. 972), the brow ridges are far more pronounced, more so than in any Australian skull which has passed under my inspection, but the index is only 35·8; this is not due to any shortening of the nasi-ophryon line, which measures 34 mm., but to the increased length of the ophryo-bregma chord, which amounts to 95 millims. Both these indices, however, are considerably above those observed in recent skulls by SCHWALBE, who gives 31·8, from the skull of a "Dschagga" negro, as the highest he has met with.*

The glabellar index in the Neandertal group of skulls has the following values:—Neandertal, 44·2; Spy I, 41·5; Spy II, 34·4 (?); Gibraltar, 43 (?).

Two other important differences, not hitherto insisted on, contribute to distinguish the glabellar region of the Neandertal from that of the Australian skull. They find expression in the measurements given in the following table:—†

	$\nu\iota$.	$\gamma\iota$.	$o\iota$.
Neandertal	192	199	186
Spy I	—	—	—
Spy II.	186	191	180
Gibraltar.	182	188	181
Australian	184	190	186

It will be seen that the glabella-inion line, which except in the Gibraltar skull corresponds with the maximum length, is longer than the ophryo-inion line, but much more so in all the members of the Neandertal group than in the Australian skull No. 998; this is due to the fact that the glabellar fossa is strongly marked in the former, and barely existent in the latter. It is, indeed, largely owing to the presence of its associated fossa that the torus in the Neandertal skulls, as in the anthropoid apes, stands out in such high relief. In Australian skulls the fossa is generally better expressed over the brow ridges than above the glabella.

It will be observed in the next place that the nasi-inion line is shorter in the Australian skull than the ophryo-inion line, while in the Neandertal group the reverse is the case. This may be correlated with a second distinction of at least equal importance, which may be most readily recognised by a reference to the profiles of the Gibraltar skull and of the Australian, No. 998 (figs. 18, 20). In the latter the nasal bones, which become rapidly narrower upwards, are pinched in as it were, and pressed under the glabella, so that the nasion is situated at a point of abrupt contrary flexure. It is to this feature that the male Australian skull in general owes

* G. RUGGERI has also pointed out that this value is exceeded in Melanesian skulls, and he gives one instance in which it attains 39·7, 'Atti della Soc. Romana,' 1901, vol. 8, p. 21.

† The following abbreviations are used throughout for points:—ν, nasion; γ, glabella; o, ophryon; β, bregma; λ, lambda; ι, inion; $o\pi$, opisthion: b, basion; $\pi\rho$, sphen-ethmoidal; pr, prosthenion; and for lines, $\gamma\iota$, from glabella to inion, and so on. Measurements are given in millimetres.

much of its ferocious appearance. In the Neandertal, as represented by the Gibraltar skull, the nasals are very broad at the upper end, and instead of terminating at the point of contrary flexure are continued upwards with gently flowing outline into the curve of the glabella itself, so that the nasion is situated some 4 or 5 millims. above the bottom of the trough which marks the passage from the nasal to the glabellar region. This is a primitive character, met with in the higher apes and in young children (five years) of European races.

The magnitude and continuity of the frontal torus, the accompanying supra-toral fossa which gives emphasis to it, and the confluent passage into its curvature of the nasal bones are all characters of great significance. The glabella, which contributes to the composition of the torus, shares its importance; but when, after full appreciation of this fact, we have assigned to the glabella its value as expressed by its index, we must be careful in subsequent analysis to eliminate its influence as far as possible; for to introduce it into fresh measurements of other characters would be to count it over more than once and thus to exaggerate its part. Such a proceeding is all the more dangerous since its real nature may be cloaked only too easily under the obscurity of statistics. Yet the magnitude of the glabella certainly has this illegitimate effect in several of SCHWALBE's measurements, such, for instance, as the frontal angle, the altitudinal index, and the so-called bregma angle. This follows from the fact that the line which this distinguished anatomist selects as a base is drawn from the glabella to the inion, so that the glabella contributes to its length; a line from nasion to inion would have been less open to objection, a fact recognised by SCHWALBE, for he remarks that this would have certainly afforded a more rational base, and only rejects it on the ground that the difference in the base scarcely affects the general results. So far as the Neandertal calotte when considered alone is concerned, this is doubtless correct, but the fact is overlooked that the effect becomes more considerable when this skull is brought into comparison with others in which the glabella is less strongly pronounced. In any case, "die rationellere Basallinie," *i.e.*, the nasi-inion line, would seem to offer the safer guidance and we shall therefore adopt it, at the same time giving measurements founded on the glabella-inion line for comparison with the results obtained by SCHWALBE.

The Calottal Height.—This is determined by a perpendicular dropped from the vertex of the cranial vault on to the nasi-inion line (*vh*, fig. 1.) In the Australian skull (No. 998) it measures 87·5 millims.; in the Neandertal, according to SCHWALBE, 88 millims. The altitudinal index of the calotte is obtained by multiplying the height by 100, and dividing by the length of the nasi-inion line, which in the Australian skull measures 184 millims., and in the Neandertal, 192 millims.; the index for the latter is thus 45·8, for the former 47·5.

If, in accordance with the practice of SCHWALBE, we measure the height from the glabella-inion line (*v'h'*, fig. 1), we obtain a value of 85·5 millims., which gives an index of 45 in the case of the Australian skull; in the case of the Neandertal, we have a height of 80·5 millims. according to SCHWALBE, which gives an index of 40·5, or a height of 84 millims. according to KLAATSCH, and an index of 42·2. It is interesting to observe how closely the index obtained by KLAATSCH accords with that which may be calculated from the measurements of an Australian skull in the collection of the Royal College of Surgeons made by HUXLEY, who found a height of 3·4 inches, as measured from the glabella-inion line, and a length of 8 inches; the index is consequently 42·5. HUXLEY, in comparing the Neandertal with some Australian skulls, found for one of the latter a calottal height of 3·8 inches, and a maximum length of 7·8 inches; its index was therefore 48·1.

Summarising our results, we have the following:—

	Height above $\nu\iota$.	Index.	Height above $\gamma\iota$.	Index.
Neandertal	88	45·8	80·5	40·5 (SCHWALBE)
"	—	—	84·0	42·2 (KLAATSCH)
Spy I	?	?	81·0	40·9 (SCHWALBE)
Spy II	?	?	87·0	44·4 (SCHWALBE)
Australian (998)	87·5	47·5	84·0	44·2

SCHWALBE asserts that he has not found among the lowest races of existing men a lower index than 52, but immediately adds that he found a minimum height of 84 millims. in the skull of a "Dschagga" negro. This he dismisses, however, as an exception.

Schwalbe's Angle.—This is the bregma angle of SCHWALBE; a very unfortunate term, since no one familiar with the nomenclature of angles could interpret it otherwise than as the angle at the bregma, while it actually designates an angle at the glabella; I propose, therefore, to name it after the distinguished investigator who has introduced it into our system of measurements. It is the angle included between the bregma-glabella and the inion-glabella lines ($\iota\gamma\beta$, fig. 2). By substituting the inion-nasion and bregma-nasion lines for the corresponding glabella lines, we obtain a similar angle at the nasion ($\iota\nu\beta$, fig. 2), which we may speak of as the calottal nasion angle. In the Australian skull (No. 998) the calottal nasion angle may be calculated from the length of the nasi-bregma (109·5 millims.), nasi-inion (184 millims.), and inion-bregma (143 millims.) lines as measured with a FLOWER's craniometer; so obtained it amounts to 51° 4′, or it may be read off directly from a profile drawing of the skull; this gives a value of 51° 30′. We accept the latter result as sufficiently exact. SCHWALBE's descriptions do not afford data for calculation in the case of the Neandertal skull, but the angle may be obtained from his diagrams, which are accurately drawn to scale, and, so far as I can determine it in this way, it amounts to 47° 30′, or 5° less than in the Australian skull. I have no data for Spy I, but a measurement made on a section given by SCHWALBE afforded an angle of 54°, or 2° 30′ in excess of that found in the Australian skull.

SCHWALBE's angle is given by SCHWALBE as 44° in the Neandertal, 46° in Spy I, and 47° in Spy II, but as determined from his section it amounts to 51° 30′ in the last-named skull; in the Australian skull it is 48° 30′.

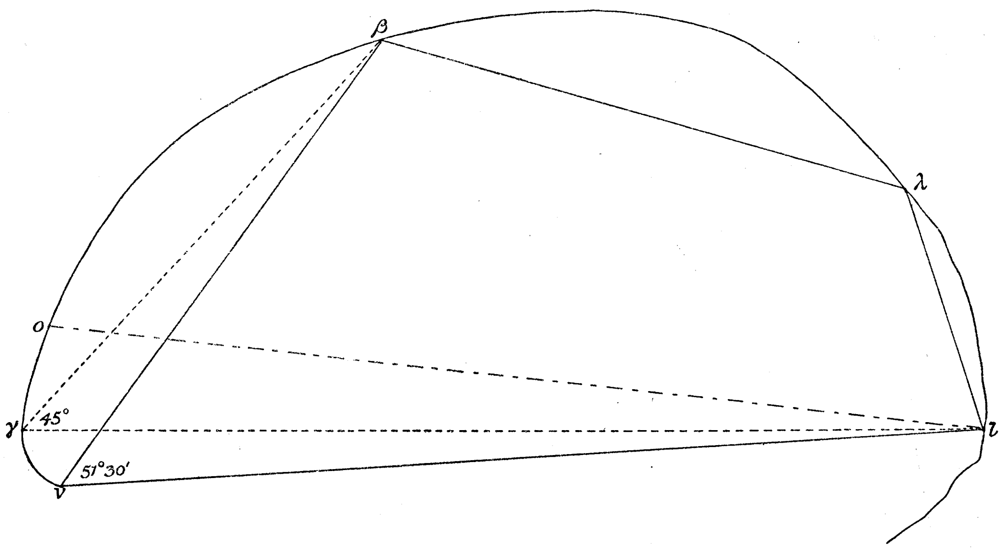

FIG. 2.—Median curve of a South Australian skull (No. 998), showing SCHWALBE'S angle ($\iota\gamma\beta$), the calottal nasion angle ($\iota\nu\beta$), and the superior inion angle ($\nu\iota\lambda$). ($\times \frac{2}{3}$.)

The Bregma Index.—If a straight line be dropped from the bregma perpendicularly upon the nasi-inion line, a point (α, fig. 1) is obtained which is the projection of the bregma upon the base (der Lage des bregma, SCHWALBE), its position may be calculated from the fact that the intercept is the cosine of the calottal nasion angle, but it is much simpler and sufficiently accurate to read off its length directly from a profile drawing of the skull;* thus in the Australian skull it measures 68·5 millims., in the Neandertal, 78 millims. in length. The bregma index is obtained by multiplying the length of the intercept by 100 and dividing by the length of the nasi-inion line; thus in the case of the Neandertal skull we have $78 \times 100/192 = 40{\cdot}6$, in that of the Australian skull, $68{\cdot}5 \times 100/184 = 37{\cdot}2$. SCHWALBE projects the bregma on the glabella-inion line (α', fig. 1), and thus obtains the following indices—in the Neandertal skull, 38·4; Spy I, 34·5; Spy II, 35·2; in the Australian skull I find an index of 36·8, which thus lies well within the limits of the Neandertal group.

The Frontal Angle.—In attempting to find a numerical expression for the retreating character of the forehead, SCHWALBE makes use of the angle included between the glabella-inion line and a tangent drawn in the median plane from the glabellar point to the most prominent part of the frontal bone ($\iota\gamma t$, fig. 3). In the Neandertal skull it amounts to 62°, in Spy I to 57° 30′, and in Spy II to 67°. In the Australian skull (No. 998) I find a value of 72° 30′, which, although 5°·5 higher than the maximum of the Neandertal group, is still 7°·5 below the minimum limit (80°) found by

* This is most readily obtained by the form of craniograph described in the Appendix (p. 337), and there termed a haptograph.

SCHWALBE in recent skulls. The frontal angle, however, is dependent on two other factors besides the retreat of the forehead, one the position of the inion, a matter we shall discuss later, and the other the projection of the glabella. In the Neandertal group, as well as in our Australian skull, the inion occupies a relatively high position, by which the magnitude of the frontal index is diminished; in the Neandertal group, again, the great glabella increases this effect.

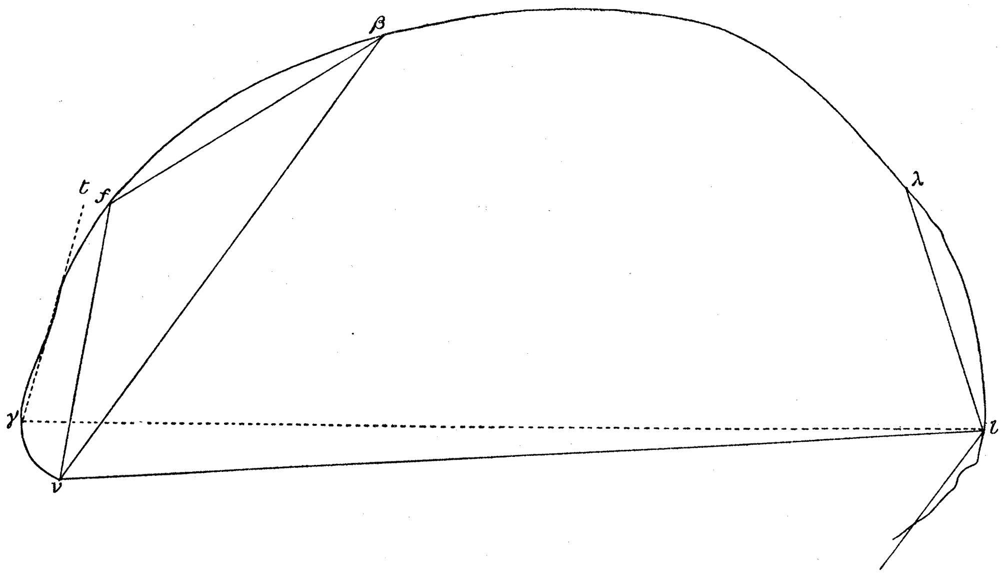

FIG. 3.—Median curve of a South Australian skull (No. 998), showing the frontal angle ($\iota\gamma t$) of SCHWALBE and the angle of curvature of the frontal bone ($\nu f\beta$). ($\times \frac{2}{3}$.)

The Orbito-frontal Angle.—The general attitude of the frontal bone may be judged, even when this element is detached from the rest of the skull, by the angle it forms with the roof of the orbit, which may be taken as approximately horizontal (fig. 4). We owe this observation to SCHWALBE, who illustrates the relation in the case of the Neandertal skull by an orthographic projection of the frontal bone, on which are represented the temporal ridge, zygomatic process, and median curve, together with a curve drawn through the median third of the roof of the orbit and continued in parallelism with the median curve on to the surface of the frontal.*

By superposing this on a similar projection of a "human" frontal bone, a difference is revealed of an "allerüberraschendste" kind. No information is afforded as to what particular race† had provided the frontal bone, but when a corresponding outline taken from our Australian skull is similarly superposed over that given by SCHWALBE of the Neandertal, the difference discovered is less surprising than the resemblance (fig. 4), that is, as regards the frontal slope; in some other respects, as, for instance, in the character of the region immediately above and behind the frontal torus, to which attention has already been directed (p. 284), a difference, or rather a contrast, is

* 'Ueber die specifischen Merkmale des Neandertalschädels,' *loc. cit.*, p. 52, fig. 8.

† A subsequent reference seems to indicate an Alsatian.

sufficiently obvious, the ophryonal fossa of the Neandertal skull presenting a contrary curvature to the arch of the frontal in the Australian skull.

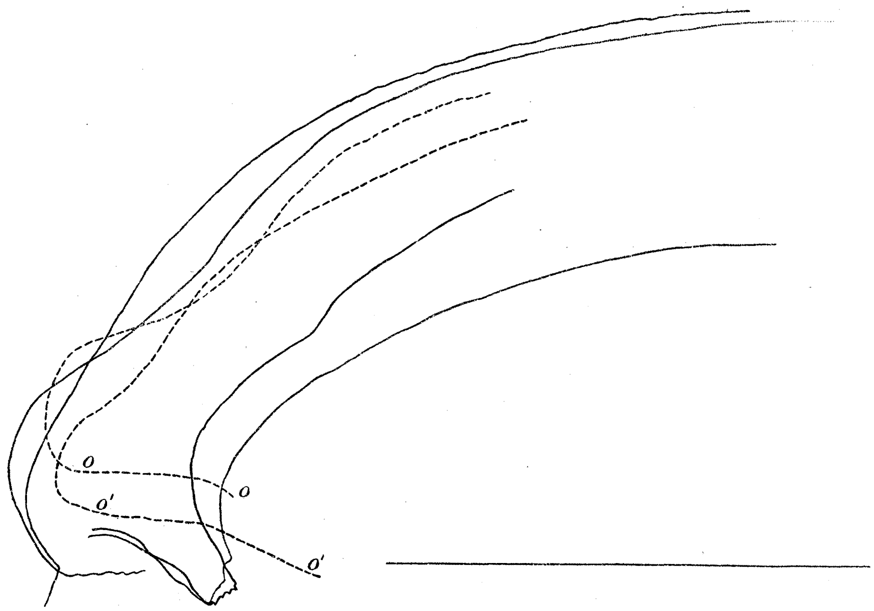

FIG. 4.—The attitude of the frontal bone in the Gibraltar skull (red outlines) and in the South Australian skull (No. 998) (black outlines); *o*, *o*, curve through the median third of the roof of the orbit in the Gibraltar skull; *o′*, *o′*, in the South Australian skull (No. 998). (Natural size.)

The Occiput.—HUXLEY remarks that:—"To an anatomical eye the posterior part of the Neandertal skull is even more striking than the anterior"; it is, therefore, of particular interest to find that the peculiarities which it presents in this region are reproduced, though not perhaps quite to the same degree, in our Australian skull. The superior and supreme semicircular lines have, in one as in the other, enlarged and fused together to form a prominent swelling—the occipital torus—and in the midst of this lies a roughened area, which represents the inion.

The Superior Inion Angle.—This has been unfortunately misnamed the "lambda" angle by SCHWALBE; it does not lie at the lambda, but at the inion; we shall accordingly speak of it as the superior inion angle, the qualification "superior" being introduced to distinguish it from the complete inion angle, which is included between the lambda-inion and the inion-opisthion lines, while the angle in question is contained by the lambda-inion line and the base ($\nu\iota\lambda$, fig. 2), which in our system of measurements is the nasi-inion, and in SCHWALBE's the glabella-inion line. Referred to our base, the angle measures 75° 30′ in the Australian skull (No. 998), 72° in the Neandertal, 73° in Spy II, and less than 80° in the Gibraltar skull, the absence of the lambda point in the last instance rendering the value uncertain. Reckoning now from SCHWALBE's base ($\gamma\iota\lambda$, fig. 2) we have 72° for the Australian skull, 66° 30′ for the Neandertal, 68° for Spy I, nearly 69° for Spy II, and something less than 74° for the Gibraltar skull. According to SCHWALBE, the smallest angle hitherto observed among recent skulls is 78°.

The Inferior Inion Angle.—This angle is included between the inion-opisthion line and the base; it is the opisthion angle of SCHWALBE. It cannot be certainly determined in the Neandertal skull owing to the imperfect state of preservation of the lower part of the occipital bone, which extends barely some 12 millims. beyond and below the inion. We shall not trouble, therefore, to give measurements from more than one base, and may content ourselves for this purpose with the glabella-inion line. SCHWALBE obtains from the Neandertal fragment a value of 51° 30′, from Spy I of 54°, and measuring from his diagram of Spy II, I obtain 53°. It is all the more remarkable to find a comparatively low angle in the case of the Gibraltar skull; it is true this has lost the opisthion, but that point cannot have been very far removed from the broken extremity which the occipital bone now presents, so that our measurement, which gives 36°, and is identical with that found by SCHWALBE, cannot be far from the truth.

Our Australian skull possesses an angle of 40°, but if a measurement be taken from the inion to a point on the occiput 23 millims. below it, an angle of 54° is obtained; this may throw some light on the high value found for the Neandertal calotte, but it will not explain the low value in the case of the Gibraltar skull; a measurement made on this to a point 23 millims. below the inion gave an angle of only 43°.

It is asserted by SCHWALBE that in recent races the inferior inion angle ranges from 31°—40°; this is not true of Australian skulls, three out of eight skulls of male South Australians gave numbers above 40° as follows: (No. 992) 42° 30′, (No. 993) 45°, (No. 999) 43°.

The Fronto-parietal Index.—This, the frontal index of BROCA, is obtained by dividing the least breadth of the frontal bone by the greatest breadth of the parietal, and multiplying the quotient by 100. In the Australian skull (No. 998) the frontal, where narrowest, measures 92 millims. across, and the parietal, where broadest, 126 millims.; the index is, therefore, 73; that of the Neandertal skull is 73·1. SCHWALBE at one time regarded this index as an important racial character, a view which he seems now to have abandoned.

The Interorbital Breadth.—Taken from the point where the *crista lachrymalis posterior* of the lachrymal bone abuts on the *pars orbitalis*, this measures only 25 millims. in our Australian skull; in the Neandertal it amounts to 30 millims., a value exceeded, however, in some other skulls from South Australia, attaining 32 millims. in one instance (No. 999).

The Cranial Capacity.—The capacity of the Neandertal skull has been estimated by various observers at 1230 cub. centims.; SCHWALBE'S calculations afford a similar result.

The breadth of our Australian skull is considerably less than that of the Neandertal, and correspondingly its circumference is shorter and its capacity smaller. The circumference of the Neandertal skull is 590 millims., of the Australian, 518 millims.; the capacity of the latter is only 1190 cub. centims., or 56·5 cub. centims. below the average capacity of Australian skulls generally, which is given by Mr. DUCKWORTH as 1246·5 cub. centims.; Sir WILLIAM TURNER, however, found a mean of 1230 cub. centims.

The few additional measurements given by SCHWALBE seem to be of subordinate importance; they may be briefly summarised as follows:—

The Difference $\gamma\iota - \gamma\lambda$.—The difference between the length of the glabella-inion and glabella-lambda lines is as follows:—

	millims.		millims.
Australian (998) .	10	Neandertal . . .	14
Spy I	14	Spy II	7
Gibraltar	11 (approximately)		

Index of Calottal Curvature.—This is obtained by dividing the maximum length by the length of the median curve of the cranial vault and multiplying by 100. Owing to the imperfection of the Neandertal fragment the measurement along the curve can only be taken as far as the inion:—

	millims.		millims.
Australian. . . .	64·6	Neandertal . . .	66·3
Spy I	70·2	Spy II	66·9

Parietal Index.—This is the length of the parietal divided by the length of the frontal and multiplied by 100:—

	millims.		millims.
Australian. . . .	96·8	Neandertal . . .	82·7
Spy I	104·3	Spy II . . .	96·7

Curvature of the Frontal Bone.—SCHWALBE measures this by the angle ($\nu f \beta$, fig. 3), included between a line drawn from the bregma on the one hand and the nasion on the other to the highest point on the frontal above the nasi-bregma line:—

	°		° ′
Australian. . . .	131	Neandertal . . .	139 0
Spy I	151	Spy II	141 30

Angular Index of the Frontal Bone.—This is obtained by dividing the length of the frontal as measured along the median curve by the nasi-bregma line and multiplying by 100:—

	millims.		millims.
Australian. . . .	87·6	Neandertal . . .	87·2
Spy I	93·9	Spy II	92·7 (?)

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

We have now passed in review the array of characters which have been supposed to indicate the existence of a broad gap intervening between the Neandertal race and modern varieties of mankind. But we have found that many of these characters, so far from establishing a difference, suggest a resemblance between the two, and that so great as almost to obliterate the void. The chief distinctive features are to be found in and about the frontal region, and have already been exposed in treating of the glabella (p. 284); the resemblances extend to the calottal height and its index, SCHWALBE'S angle, the bregma index, the frontal, orbito-frontal, superior and inferior inion angles, and the fronto-parietal index, as well as to many other characters of subordinate importance. The gap, indeed, could never have seemed so impassable if comparison had not been made too exclusively with European races.

The possession, however, of a number of characters in common by no means implies of necessity that the Australian and Neandertal men are to be assigned to the same race; such characters may have appertained to all very primitive people, and as yet we have not made acquaintance with the features of the face, without a knowledge of which it would be premature to form a final judgment on this point. Nor must the fact be overlooked that so far we have confined our attention to the evidence provided by a single skull; this is a defect which we must now proceed to remedy.

The collection of South Australian skulls in the University Museum numbers some 12 specimens, picked up at random by different observers at various localities in Victoria; eight of them are skulls of men, three of women, and one of a youth of about 14 years of age; the male skulls may be considered separately.

As a preliminary, we must first consider our choice of a base, and this renders it necessary to discuss the significance of the nasi-inion line. The inion is a feature which owes the greater part of its importance to the fact that by a piece of extraordinary good fortune it is preserved in the Neandertal calotte, and thus affords a welcome means of comparison, but it has acquired a connotative significance of perhaps deeper import, since it has been brought into connection with the form of the brain; thus HUXLEY writes: "... when I had placed the outline of the Neandertal skull against that of the Engis skull, in such a position that the glabella and occipital protuberance (inion) of both were intersected by the same straight line, the difference was so vast and the flattening of the Neandertal skull so prodigious ... that I at first imagined I must have fallen into some error. And I was the more inclined to suspect this as in ordinary human skulls the occipital protuberance and superior semicircular curved line on the exterior of the occiput correspond *pretty closely* with the 'lateral sinuses' and the line of attachment of the tentorium internally. But on the tentorium rest ... the posterior lobes of the brain, and hence the occipital protuberance and the curved line in question indicate *approximately* the lower limits of that lobe. Was it possible for a human being to have the brain thus flattened and depressed, or, on the other hand, had the muscular ridges shifted their position?" These alternatives do not seem to me mutually exclusive; HUXLEY, however, after an examination of photographs, for he had no opportunity of making direct observations on the skull, concludes as follows: "It was clear, therefore, that I had not erred in my interpretation, and that the posterior lobe of the Neandertal man must have been as much flattened as I suspected it to be."*

In his identification of the inion, HUXLEY has been shown to have been perfectly correct: his judgment with regard to the brain is invalidated by his omitting to perceive the importance of the qualification he had himself introduced. I refer to the words "pretty closely" and "approximately" which are italicised in the quotation. In ordinary human skulls the approximation is indeed as a rule very close, but even in such examples as are provided by our dissection tables there are occasional exceptions in which the outer inion is found at a higher level than the corresponding protuberance in the interior. Thus ANDERSON,† in a valuable paper on the thickness of the skull, mentions the fact that out of 154 examples measured by him there were four in which this was the case, and in one instance the outer was "much higher" than the internal inion. RIEGER also‡ states that out of 36 skulls of which the interior was exposed he found only 15 in which the outer and inner protuberance occurred at the same height, two in which the outer stood higher than the inner, in the one case 10 millims., and in the other 15 millims., and 19 in which it lay lower, with a maximum difference of 10 millims. My own observations on European skulls are in accordance with these results,§ and in the lower races, especially the Australians, the inion not uncommonly occupies a position above that of the inner protuberance, sometimes to the extent of 23 millims. The same relation is observed in all the accepted examples of the Neandertal race, *i.e.*, the inion in these skulls is situated notably higher than the internal protuberance. FRAIPONT and LOHEST, in their description of the Spy crania,‖ call particular attention to this point: they affirm that the position indicated for the external occipital protuberance does not correspond with the internal protuberance, the latter being situated below and in front, to the extent of about 10 millims., and they conclude that since the boundary of the external semicircular lines is shifted up more than 10 millims. above the *sinus lateralis*, it does not indicate the lower boundary of the posterior lobes; these, they add, were elongated, well developed, and less flattened than might

* HUXLEY, 'Man's Place in Nature,' p. 140.

† R. J. ANDERSON, "Observations on the Thickness of the Human Skull," 'Dub. J. Med. Sci.,' 1882, vol. 74, p. 270.

‡ 'Eine exacte Methode der Craniographie,' C. RIEGER, Jena, 1885, p. 21.

§ TOPINARD may also be cited: he says of the inion, "C'est que par hasard il se trouve au niveau de l'inion interne, mais que la règle, c'est le défaut de correspondance," 'Éléments d'Anthropologie Générale,' Paris, 1885, p. 656.

‖ FRAIPONT and LOHEST, "La race humaine de Neandertal ou de Canstadt en Belgique," 'Arch. de Biol.,' 1887, vol. 7, p. 623.

have been supposed from observations made on the corresponding region of the exterior of the occiput.

SCHWALBE, likewise, in the case of the Neandertal skull, admits that the interior protuberance was situated some distance below the inial ridge which connects the outer tori of the occipital.

KRAMBERGER, finally,* after stating that the occipital bones obtained by him at Krapina exhibit both the inner and outer protuberances, adds that the latter are situated above the former to the extent of 23 millims.

It is thus evident that the inion does not possess the special significance which HUXLEY claimed for it; like most muscular attachments it is liable to displacement, fluctuating above or below the inner protuberance even to the extent of 23 millims; its range is not trifling even when compared with the total length of the median curve of the skull, and may affect profoundly the angular measurements which SCHWALBE has based on the glabella-inion line.

The danger of trusting to this base may be illustrated by an instance in which we are able to control our observation by other characters. We select the Alsatian skull, of which SCHWALBE has given an illustration in more than one of his memoirs,† and compare it with that of an Australian on the basis of the glabella-inion line. On superposing the outlines (fig. 5), the difference revealed is not a little astonishing and recalls the feeling of surprise with which HUXLEY viewed the Engis and Neandertal skulls when similarly compared. The region below the datum line is perceived to have suffered a modification as remarkable as that which has affected the region above; the Australian skull rises in the air so that the occipital foramen lies within the cranial cavity of the Alsatian. Have these remarkable transformations actually taken place or is it that our method of comparison is at fault? We may hope to obtain some light on this question by experimenting with other base lines.

HUXLEY remarks "I have arrived at the conclusion that no comparison of crania is worth much that is not founded upon the establishment of a relatively fixed base-line, to which the measurements in all cases must be referred. Nor do I think it a very difficult matter to decide what that base-line should be." The base-line advocated by HUXLEY was the basi-cranial axis as defined by him: of its importance there can be no doubt, its fixity is another matter; but independent of theoretical considerations there is one very serious practical difficulty which stands in the way of its adoption, since in order to determine it the skull must first be sawn in two, and thus rendered less valuable for other observations. Consequently, notwithstanding the opinion expressed by HUXLEY that it should be "an opprobrium to an ethnological collection to possess a single skull which is not bisected longitudinally," there is scarcely any large collection in which more than one skull out of 50 has been

* GORJANOVIĆ-KRAMBERGER, "Der diluviale Mensch von Krapina," 'Biol. Centralblatt,' 1905, vol. 25, p. 805.

† SCHWALBE, 'Anatom. Anzeig.,' *tom. cit.*, fig. 10, p. 54.

so treated, the curators of such collections evincing a not unnatural reluctance to mutilate the specimens committed to their care. For the present, therefore, we must content ourselves with the nearest substitute which can be obtained from measurements of the exterior; this may be either the nasi-basal or the ophryo-basal line. There is much to be said in favour of the latter; the nasi-basal, however, has the great advantage of being more definitely determinable.

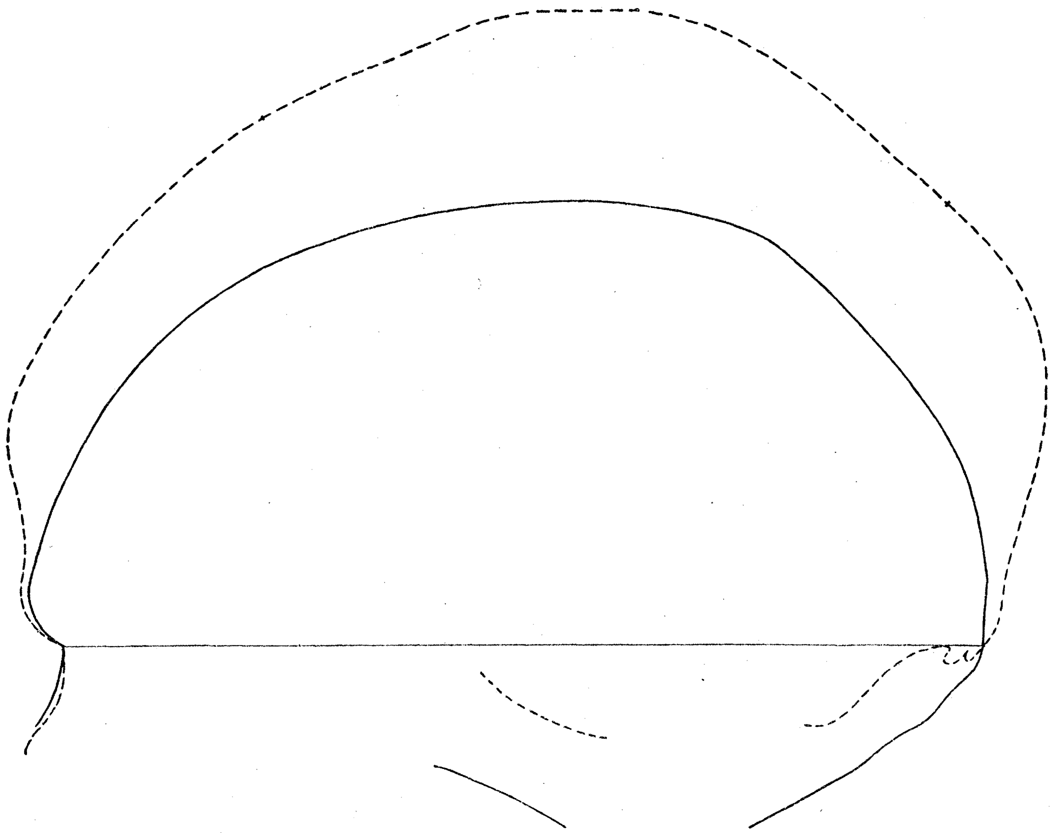

FIG. 5.—Median curve of the South Australian skull, No. 998 (continuous line), compared with that of an Alsatian skull (broken line) by superposition upon the nasi-inion base. ($\times \frac{2}{3}$.)

But we cannot avoid the theoretical difficulty. Is it actually certain that any relatively fixed base exists in the cranium? The one thing constant which I can perceive among human skulls is their variability, and the basi-cranial axis is subject to displacement and change of form to the full as much as any other cranial feature. Where every point is shifting, the search for a unique system of comparison would seem foredoomed, and our endeavour to represent the distribution of the displacements which affect the various regions of the skull can only be satisfied by comparisons made on several base lines.

Of the numerous base lines—all unsatisfactory—which may be obtained by measurement of the exterior, there are three, each of which seems to possess some special advantage of its own. These are the foraminal base, the nasi-basal axis and a "horizontal line."

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As regards a horizontal line, there can be little doubt that BROCA's "binorbital" line is the most logical in conception, but there is room for further refinement in the method of defining it: the alveolo-condylar line of the same author has the merit of being easily determined, and lies as a rule fairly parallel with the binorbital, though in some cases it may be divergent to the extent of 10°. The Frankfort line, drawn from the lower margin of the orbit through the upper margin of the auditory meatus, is sometimes fairly concordant with the binorbital line, sometimes with the alveolo-condylar, and affords as useful a guide as either: in some cases, particularly in the more primitive forms of Australian skull, it accords with the binorbital line more closely than the alveolo-condylar does, and this is a fortunate circumstance, since it is the line we are compelled to adopt in the present investigation, owing to the absence of those features from the Neandertal skulls on which the determination of BROCA's lines depends. The relations between the three lines in our group of South Australian skulls are shown in the following table, the angles being reckoned from the basi-central (see p. 299) as the initial line:—

Skull.	Orbit.	Frankfort.	Alv.	Skull.	Orbit.	Frankfort.	Alv.
	°	°	°		°	°	°
991 *m*	93·5	89·5	93·5	997 *f*	101·5	100·5	105·0
992 *m*	88·5	88·5	90·5	998 *f*	95·0	93·5	98·0
993 *m*	95·5	94·0	96·5	999 *m*	97·0	96·0	102·0
994 *m*	105·5	98·0	106·0	1000 *f*	97·5	99·0	107·0
995 *m*	100·0	96·0	101·0	1001 *f*	101·0	96·5	102·0
996 *m*	95·0	96·0	100·0	1002 *m*	111·0	103·0	113·0

m Male. *f* Female.

A horizontal line differs from a true base, inasmuch as it may be regarded as a direction only, so that in superposing cranial profiles for purposes of comparison, we need not register them directly on the Frankfort line, but simply in parallelism with it: the registration being completed by means of some fixed point, such, for instance, as the centre of the occipital foramen.

The effect of superposing the profiles of eight male skulls of South Australian aborigines in this way is shown in fig. 6.

The foraminal axis offers a simple means of comparison, enabling us to read off readily the exterior foramino-basal angle, or that contained by the nasi-basal line and the long axis of the foramen magnum. It will be perceived that this differs from the true foraminal-basal angle of TURNER, which can only be determined by bisecting the skull. Using the foraminal axis as a base, with the basion for a fixed point, the eight profiles just referred to have been superposed as shown in fig. 7.

The effect of using the foraminal axis as our fixed line is to throw the whole of the displacement of the cranial base on to the nasi-basal lines, an unfair proceeding, but the result is equally disastrous when this line or the ophryo-basal is made the

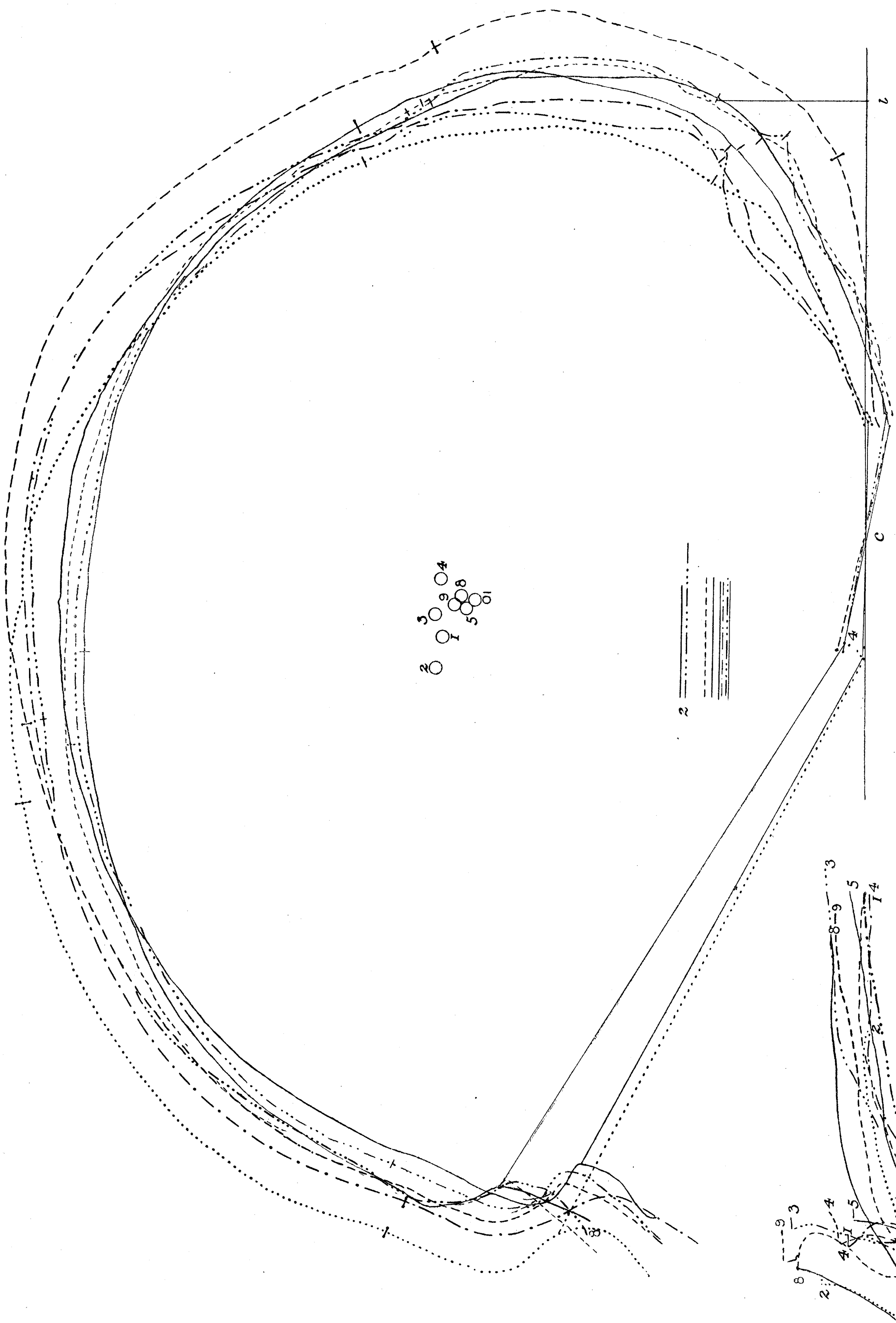

FIG. 6.—Profiles of eight skulls of South Australian males, superposed on the centre of the occipital foramen in parallelism with the Frankfort line. The skulls are numbered 1, 2, 3, 4, 5, 8, 9, and 01. The numbered circles in the middle correspond to the respective centres of figure. (Natural size.)

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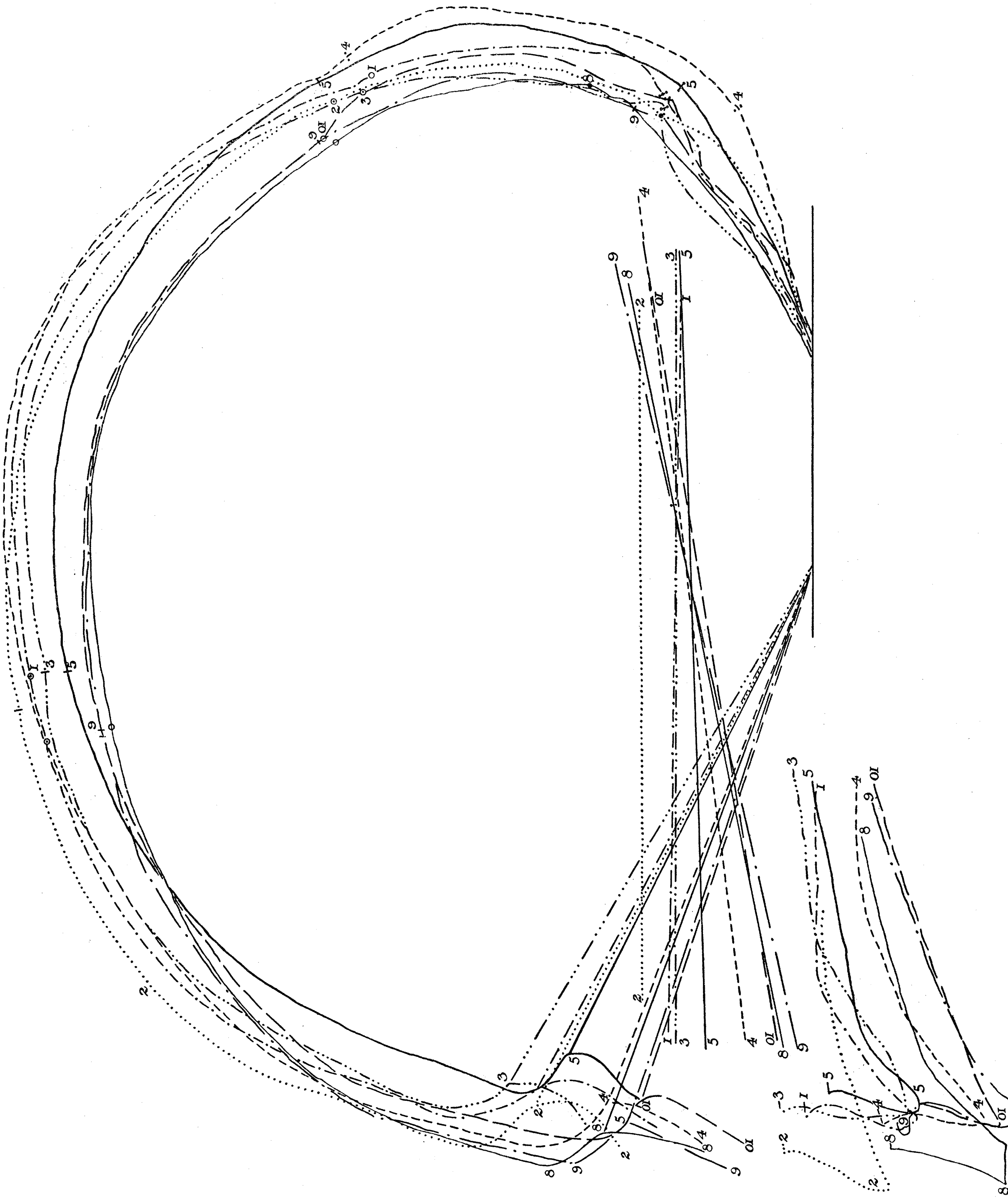

FIG. 7.—The same profiles as those shown in fig. 6, superposed on the foraminal axis. The isolated straight lines are the Frankfort lines. (Natural size.)

base, all deviation from the average being then concentrated in the occipital region. The eight profiles are shown superposed on the ophryo-basal line in fig. 8.

There remains still one other method of comparison, which may usefully supplement the three preceding; it may be regarded as a modification of BROCA'S system of auricular angles, the centre of figure being substituted for the centre of the auditory meatus, so that the angular points are represented more nearly in their natural relations. The first step is to find the centre of the figure formed by the curvilinear profile and the nasi-basal line: this may be accomplished with sufficient accuracy by tracing the outline on thin Bristol cardboard, cutting it out and finding the centre of gravity; this corresponds with the centre of figure. By joining the centre with some recognised anatomical point, such as the basion, we obtain the initial line from which to measure our angular distances. Every point in the profile can then be represented by the length and angular position of the radius drawn to it from the centre. Relations of direction, such as are given by the horizontal lines, may also be expressed by radii in this system of polar co-ordinates.

It may be noted that the initial line, if taken from the basion, will be found to pass through the auditory meatus, or rather through its orthographic projection on the plan of the profile; again, if such an initial line be produced as far as the cranial vault, it will afford one of the most consistent measures of the cranial height.

It would be reasonable, when the upper jaw is taken into account, to take a fresh centre, that, namely, of the whole skull instead of that of the cranium only: I find upon experiment, however, that the substitution is of no practical importance.

On the whole I think this method gives the clearest, simplest, and most complete expression to the facts, and with greater fairness than any other. A comparison of the eight Australian skulls made by means of it is given in fig. 9.

But whatever opinion we may form as to the relative value of these various methods of representation, it will probably be admitted that they are each and all preferable to any based on the glabella-inion line, so that we may safely make use of them in studying the behaviour of the inial point. The eight profiles belong to a natural series, of which No. 998 is the lowest member; the two others which make the closest approach to this are numbered 999 and 1001; 999 is indeed very nearly allied, though it would scarcely appear to be so if the calotte alone were compared on the glabella-inion base.

On examination of figs. 6 and 7, it will be seen that the inia are for the most part closely clustered together, and if this were true of all of them the inion might afford a trustworthy fixed point. There are, however, two obvious exceptions, one afforded by No. 998, in which the inion occupies a much higher position than in the rest, and the other that of No. 994, in which it is abnormally low; the inion in these cases is situated about 12 millims. on either side of the average level. The effect of superposing the calottes of these two skulls on the glabella-inion line is to exaggerate the apparent difference between them, especially as regards the calottal height; thus the

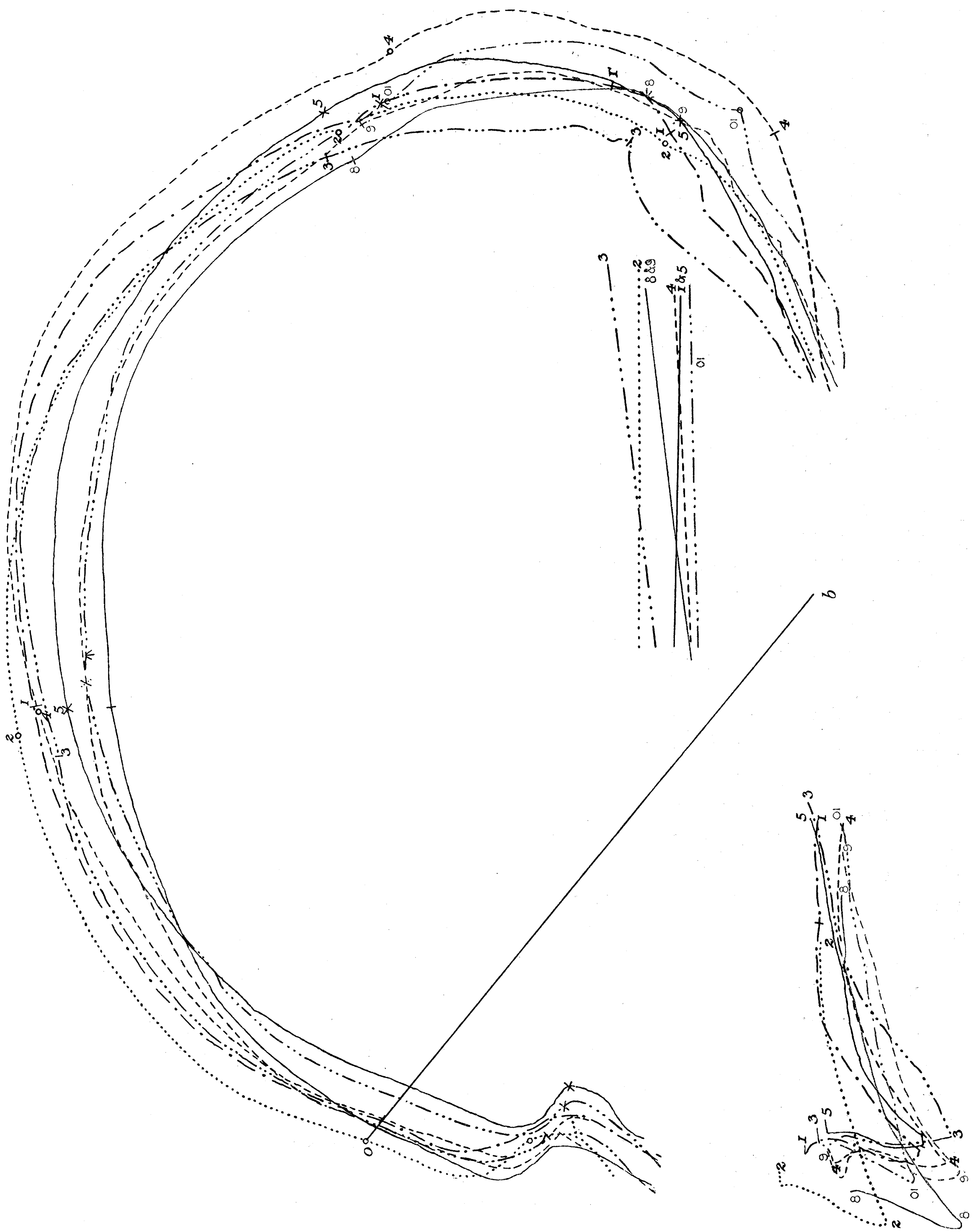

FIG. 8.—The same profiles as the preceding, superposed on the ophryo-basal line. The Frankfort lines are indicated by the numbered straight lines. (Natural size.)

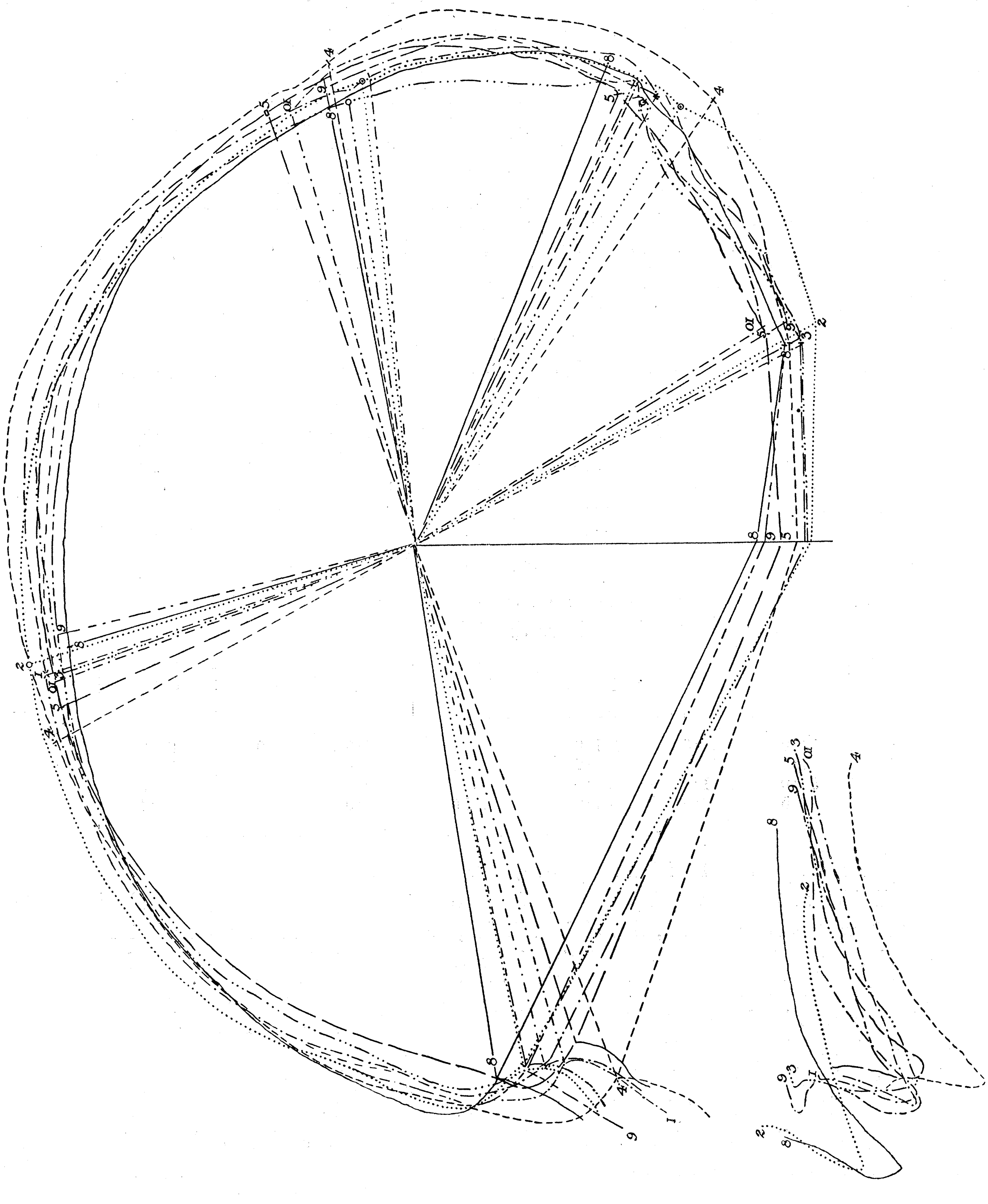

FIG. 9.—The same profiles as the preceding, superposed on the centre of figure and the centro-basal line. (Natural size.)

true maximum height measured from the basion is 124 millims. in No. 998 and 142 millims. in 994, a difference of 18 millims. only, while the calottal height measured from the glabella-inion line is 84 millims. in No. 998 and 125 millims. in No. 994, a difference of 42 millims., or more than twice as much as the true difference.

It is clear that the inion cannot be regarded as a fixed point; it is possible, however, that its position may prove to afford a useful racial character, and we may attempt, therefore, to find some form of expression for it. It may be defined in more than one way, either as the ratio of the opisthion-inion and inion-lambda chords, according to the formula $o\pi\iota \times 100/\iota\lambda = index$, or as the tangent of the angle ($\iota b o$) formed at the basion by the foraminal axis and the basi-inion chord.

Taking the latter first, we have the following results :—

Number.	Angle.	Index.	Capacity.	Number.	Angle.	Index.	Capacity.
	° ′		c.c.		° ′		c.c.
991	16 42	30·00	1295	995	15 47	28·65	1190
992	18 24	32·27	1375	998	25 51	48·44	1190
993	18 27	33·75	1170	999	21 49	40·0	1310
994	8 53	15·63	1470	1001	17 9	30·86	1275

Thus for these skulls the average index is 32·45, and the departure from the mean is +15·99 on the one side and −16·82 on the other.

According to the first formula we have the following :—

Number.	$\lambda\iota$.	$\iota o\pi$.	Index.	Number.	$\lambda\iota$.	$\iota o\pi$.	Index.
991	51·0	51·5	101·0	995	62·5	50	80·0
992	57·0	46·0	80·7	998	49·0	59	120·4
993	53·0	51·0	96·2	999	55·5	51	91·9
994	68·5	46·0	67·2	1001	63·0	50	79·4

giving an average of 87·1 with a range of +33·3 and −19·9.

Skull No. 994, with the highest capacity, presents the lowest index, and skull No. 998, with a low capacity, the highest index, but nothing can be inferred from this, since in other cases the relation is reversed; thus No. 995 unites a low capacity with a low index, and No. 999 a fairly high capacity with a high index, nor can any connection be traced between the index and the degree of prognathism or the position of the geometrical centre of the calvarium.

The significance of the inion is, in the first place, physiological, and we may consider it in connection with fig. 6, in which the head is represented in a more or less natural attitude, when it is steadied on the occipital condyles by the play of the nuchal muscles. A line drawn from the instantaneous centre of rolling contact provided by the occipital condyles to the inion may be taken to represent the lever through which the muscles act, but it will be sufficient for our purpose to replace this by the basi-inion line. By projecting this on a line drawn through the basion parallel to the Frankfort line, we obtain the efficient length of the lever when the head is at rest. It will still further simplify matters if we substitute the centre of the foraminal axes (which is their common point of intersection in the diagram) for the basion in this proceeding; we then find, taking all the eight skulls, that the mean length of the effective lever (*cl*, fig. 6) is 63·8, with a range on each side of +7·2 and −5·8, or a difference of 20 per cent. When the head is so far rotated that the line $c\iota$ is brought into correspondence with the line *cl*, and thus reaches its maximum efficiency as a lever, this difference is reduced to 17·6 per cent. The further consideration of the question is complicated by several other factors, but in any case a high inial index is connected with a mechanical advantage, and though this may not be a matter of great importance as regards ordinary movements of balancing, it becomes so when the head is used as an additional organ of prehension, as in tearing flesh from bones and in other ways. Thus a high inial index may be correlated with brutal habits, and may well be an inheritance from simian ancestors.

We may now proceed to compare our Australian skulls on the one hand amongst themselves and on the other with the fossil remains of lower palæolithic age. The two groups are fair matter for comparison, for both are chance collections.* The Neandertal group comprises the two well-preserved calvaria from Spy, the nearly complete Gibraltar cranium, and the Neandertal calotte itself, together with others less complete, of which the affinities must remain for the present doubtful. The fragmentary remains from Krapina certainly belong to the Neandertal race, but they are of little avail for our immediate purpose, since none of them retain their original connection, not even to the extent of forming a cranial calotte. It is true that a calvarium has been described and figured, but this owes its existence to the constructive ingenuity of Professor GORJANOVIĆ-KRAMBERGER, the distinguished discoverer of the remains, who informs us that he built it up of bones belonging to different individuals of about the same age, as nearly as he could judge; it is on measurements of this artifact that the supposed extreme brachycephaly of the Krapina race has been based.

The Cephalic Index.

Number.	Length.	Breadth.	Index.	Number.	Length.	Breadth.	Index.
991	188	130·5	69·40	995	187	131	70·1
992	189	133·0	70·37	998	190	126	66·04
993	180	129·0	71·67	999	191	138	72·2
994	200	139·0	69·5	1001	190	130	68·4

* This is less true of the Neandertal than the Australian skulls, for the former are united into a group from which other ancient skulls are excluded chiefly on anatomical grounds; in this respect they are selected specimens.

The mean index is 69·71 with a variation of 2·49 and −3·67. The index obtained by DUCKWORTH from a large number of skulls not exclusively South Australian but from all parts of the Continent is 70·95.

Ratio of Frontal and Parietal Bones in Length.

Number.	Fr.	Pa.	Index.	Number.	Fr.	Pa.	Index.
991	131	137	104·6	995	125	120	96·0
992	130	130	100·0	998	127	117	92·1
993	122	128	104·9	999	132	116	87·9
994	132	147	111·3	1001	130	120	92·3

The last four skulls show a marked inferiority to the first four in respect to this ratio, which, as will be seen on reference to p. 291, varies widely within the Neandertal group as in human skulls generally.

Anterior Cranial Angles.—These are given in the following table, SCHWALBE's angle ($\iota\gamma\beta$) in the first column, the calottal nasion angle ($\iota\nu\beta$) in the second, and the full nasion angle ($b\nu\beta$) in the third.

Number.	$\iota\gamma\beta$.	$\iota\nu\beta$.	$b\nu\beta$.	Number.	$\iota\gamma\beta$.	$\iota\nu\beta$.	$b\nu\beta$.
991	56° 30′	58° 30′	79°	995	57° 0′	61° 0′	80° 0′
992	57 0	60 0	79	998	47 30	51 30	71 0
993	55 0	57 0	78	999	51 0	53 30	71 30
994	62 0	65 0	78	1001	54 30	58 0	73 0

The angles in the first and second columns do not afford much useful information, since they depend in great measure on the position of the inion; there is on the whole a tendency when the full angle ($b\nu\beta$) is low for both the other two to follow it in this respect, but in no constant ratio. The complete angle is more instructive; according to its magnitude the skulls may be divided into two groups, one in which it is larger and one in which it is less. The first group comprises the first five skulls on the list, the second the remaining three. In the latter the angle varies but little on each side of 71° 50′, in the former no more than 1° on each side of 79°; the difference between the two groups on the other hand amounts to nearly 7°.

The Posterior Cranial Angles.—These are tabulated below as follows :—

Number.	$\gamma\iota\lambda$.	$\gamma\iota o\pi$.	$\lambda\iota o\pi$.	Number.	$\gamma\iota\lambda$.	$\gamma\iota o\pi$.	$\lambda\iota o\pi$.
	° ′	° ′	° ′		°	° ′	° ′
991	84 30	40 0	124 30	995	82	36 0	118 0
992	82 0	43 0	125 0	998	72	42 0	114 0
993	80 0	44 30	123 0	999	79	42 30	121 30
994	87 0	25 30	112 30	1001	78	34 30	112 30

None of these angles appear to be of any great importance; they are all largely influenced by the position of the inion.

In the Gibraltar skull, which stands at a low morphological level, all three angles, so far as can be judged in the absence of the opisthion and lambda, are comparatively small.

The Height of the Cranium.—Measurements of maximum height are given below: in the first column from the glabella-inion line, in the second from the nasi-inion line, in the third from the glabella-lambda line and in the fourth from the basion point to the vertex.

Number.	$\gamma\iota$.	$\nu\iota$.	$\gamma\lambda$.	*b*.	Number.	$\gamma\iota$.	$\nu\iota$.	$\gamma\lambda$.	*b*.
	millims.	millims.	millims.	millims.		millims.	millims.	millims.	millims.
991	93	98	69·5	140·0	995	98	100	63	133
992	99	103	69·0	140·0	998	84	87	56	124
993	96	100	64·0	138·5	999	90	95	61	127
994	115	119	75·0	142·0	1001	96	99	64	127

The heights corresponding to those in the first two columns have been given for the Neandertal group on p. 286; it only now remains to add the so-called lambda calottal heights corresponding to those in the third column; they are as follows:—

Neandertal, 57 millims.; Spy I, 51 millims.; Spy II, 58 millims.; Gibraltar, 55 millims. (?); from these numbers we obtain an average of 55·2 with a variation of +2·8 and −4·2 millims. The average of the "lambda" heights of the South Australian skulls is 65·2 millims., the variation +9·8 and −9·2; thus the difference between the means for the two groups is no less than 10 millims. and if the range of variation was as great among the Neandertal people as among existing races they would have presented a maximum "lambda" height of 55·2 + 9·8 millims. = 65 millims., or nearly the same as the average among the South Australian skulls, and a minimum of 55·2 − 9·2 = 46 millims., thus approaching the skull of Pithecanthropus.

The relation of the height above the glabella-lambda line to that above the basion is not without interest; it is not constant, but the limits within which it varies are not excessive. This may be seen from the following series of indices obtained by dividing the height taken from the glabella-lambda line by that taken from the basion and multiplying by 100.

Number.	Index.	Number.	Index.	Number.	Index.	Number.	Index.
991	49·6	993	46·9	995	47·4	999	48·0
992	49·3	994	52·8	998	45·1	1001	50·4

The average is 48·7 with a range of −3·6 and +4·1.

The average height above the basion is 134 and, as we have seen, the average height above the glabella-lambda line is 65·2; if the same relation was maintained among the Neandertal race then its average height of 55·2 above the glabella-lambda line should correspond to a height of 113·3 millims. above the basion. But the "lambda" height of the Gibraltar skull cannot be very far from the average, 56, and measurements of its probable height above the basion afford the number 120–122 millims. By parity of reasoning the probable maximum height of the Neandertal skull was within 3 or 4 per cent. of 122 millims., of Spy I of 109 millims. and of Spy II of 124 millims.

The Bregma Angle.—The true bregma angle formed by the ophryo-bregma and lambda-bregma lines has the following values:—No. 991, 110°; No. 992, 116°; No. 993, 115°; No. 994, 111°; No. 995, 114°; No. 998, 122°; No. 999, 119°; No. 1001, 115°.

A high angle might be predicated of a low skull, and the connection is suggested by the table, though the angle of 1001 is unexpectedly large.

The Angles at the Base.—Very considerable interest attaches to the anterior of these angles, that is the angles *νboπ* and *oφboπ* made by the nasi-basal and ophryo-basal lines respectively with the posterior cranial base. They are the best substitutes we can obtain by exterior measurement for that which Huxley called the occipital angle. The general principles enunciated by Huxley regarding the increasing value of this angle as we pass from the lower animals to man are indefeasible; but within the limits of the human race the law of increment is not so simple as Huxley supposed, but is subject to anomalies, which have troubled anthropologists not a little. Their consideration will involve a somewhat long discussion.

Number.	*νboπ.*	*oφboπ.*	*boπι.*	*boπλ.*	Number.	*νboπ.*	*oφboπ.*	*boπι.*	*boπλ.*
	° ′	°	° ′	°		° ′	°	° ′	°
991	152 0	140	34 30	57	995	153 30	140	33 0	62
992	152 0	140	34 64	64	998	162 0	148	42 30	63
993	149 30	136	33 0	61	999	162 0	148	40 0	70
994	159 0	144	16 0	57	1001	162 0	149	30 0	64

It will be seen from the above table that the last three skulls, which in most other respects bear the stamp of inferiority, are distinguished by the magnitude of the exterior foramino-basal angle, which whether measured from the nasi-basal (*νboπ*) or from the ophryo-basal (*oφboπ*) line, is larger than in any other member of the series. This is the reverse of what, arguing from general principles, we might have expected. The angles *boπι* and *boπλ* or rather their supplements have been added to the table in order to discover whether they displayed any compensatory variation, but it is sufficiently obvious that the two sets of angles vary independently.

In children, as is well known, the occipital angles including those given above are larger than in the adult, and this fact suggests that a clue to the difficulty may perhaps be found by comparing the skulls of men as well as of anthropoid apes in different stages of growth. Let us see if this is the case. The skull of a young chimpanzee, No. 1 in the diagram (fig. 10), is more human than many men as regards the magnitude of its exterior foramino-basal angles ($\nu bo\pi = 154°$ and $o\phi bo\pi = 139°$), which are at least 3° greater than the corresponding angles in the South Australian skull No. 993. In the adult (No. 4, fig. 10) they are 130° and 115°

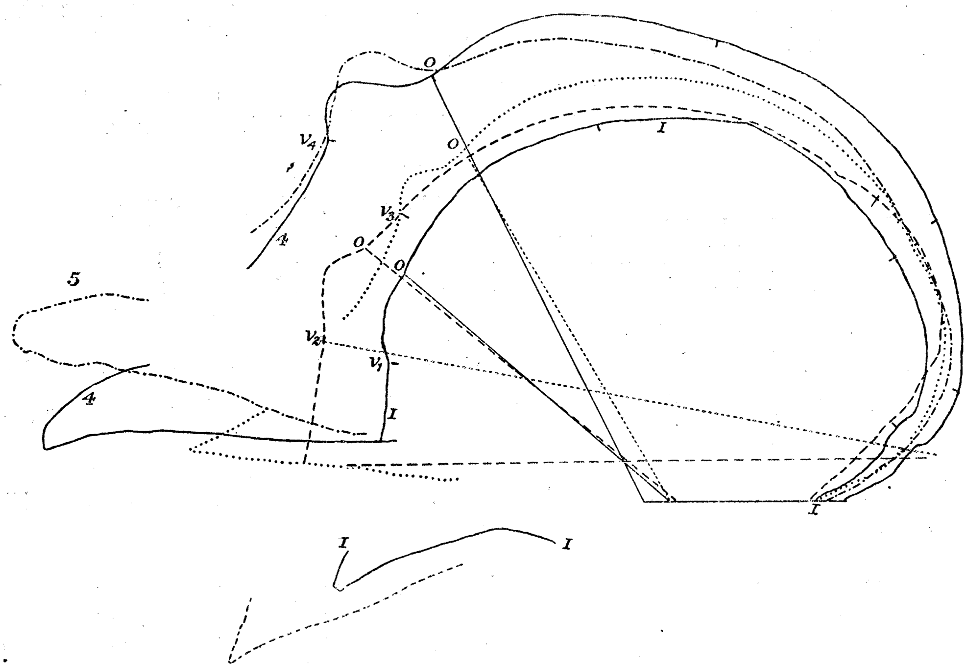

FIG. 10.—Median profiles of five skulls of Chimpanzees in various stages of growth, superposed on the foraminal axis. The red lines are the Frankfort lines, the upper one of profile No. 3, the lower of profile No. 2. ($\times \frac{2}{3}$.)

respectively. The explanation lies very close at hand: the brain of the anthropoid ape suffers an early retardation of growth amounting almost to an arrest, such increase in size as does take place being chiefly in a longitudinal direction; correspondingly, the cranium enlarges but little, and that in length; thus the exterior measurement of the curve of the calvarium from the opisthion to the ophryon gives a very similar result for both the young and adult chimpanzee, being 180 millims. for Skull No. 1 and 186 millims. for Skull No. 4, even this slight difference of 6 millims. being chiefly due to the increased thickness of the skull in the adult.

The face, on the other hand, suffers an almost complete transformation, its growth is excessive, and involves the base of the cranium, which is at the same time the roof of the face. As a natural consequence the cranial vault is rotated backwards, rising and retreating at its anterior end as the base elongates. As a part of the same movement, the base itself ascends at its anterior end and rotates backwards on the basion thus diminishing the foramino-basal angles. The effect may be very simply illustrated in the following way. A strip of elastic material is fixed at one end and at the other attached to a thread by which it is bent into an arc; on allowing the thread to lengthen, the arc rises and the stretched thread which represents the cranial base follows it, rotating backwards.

If it be true that the change of angle is due to an elongation of the basi-cranial axis, then as growth proceeds the length of the basi-ophryon line should increase at a greater rate than that of the basi-bregma line, and the length of this at a greater rate than that of the basi-lambda line. That this is actually the case is shown by the following measurements of Skulls 1 and 4 :—

	Skull 1.	Skull 4.	Increase.
	millims.	millims.	millims.
Length of basi-lambda line	66	68	2
,, basi-bregma ,, ...	75	88	13
,, basi-ophryon line . . .	68	96	28

A similar result is obtained when a larger number of skulls are compared; seven skulls of chimpanzees in the University Museum give the following numbers :—

No. of skull	1.	2.	3.	4.	5.	6.	7.	Mean.	Difference.
$b\lambda$ . . .	66	68	72	68	71	68	81	70·6	5
$b\beta$ . . .	75	80	80	83	85	88	92	84·6	10
$bo\phi$ . . .	68	75	75	80	82	96	94	84·3	16

The difference in the last column is the difference between the mean and the numbers in the first column.*

The same law of growth may be traced in the skull of the gorilla and orang. Of the gorillas in our collection only three show the cranial sutures; these have afforded the measurements given below; their profiles are superposed in fig. 11.

No. of skull	1.	2.	3.	Difference, 1 and 2.	Difference, 1 and 3.
$b\lambda$	70	77	?	—	—
$b\beta$	86	93	100	7	14
$bo\phi$	83	96	118	13	35

The orang is represented by six specimens in our collection: in the youngest of these the frontal suture is still open; in the next, not much older, this suture is

* The skulls are catalogued in the Museum collection as follows:—No. 1 is 2050*b*, No. 2 is 2048, No. 3 is 2049, No. 4 is 2047, No. 5 is 2046, No. 6 is 2049*a*, No. 7 is 2049*b*.

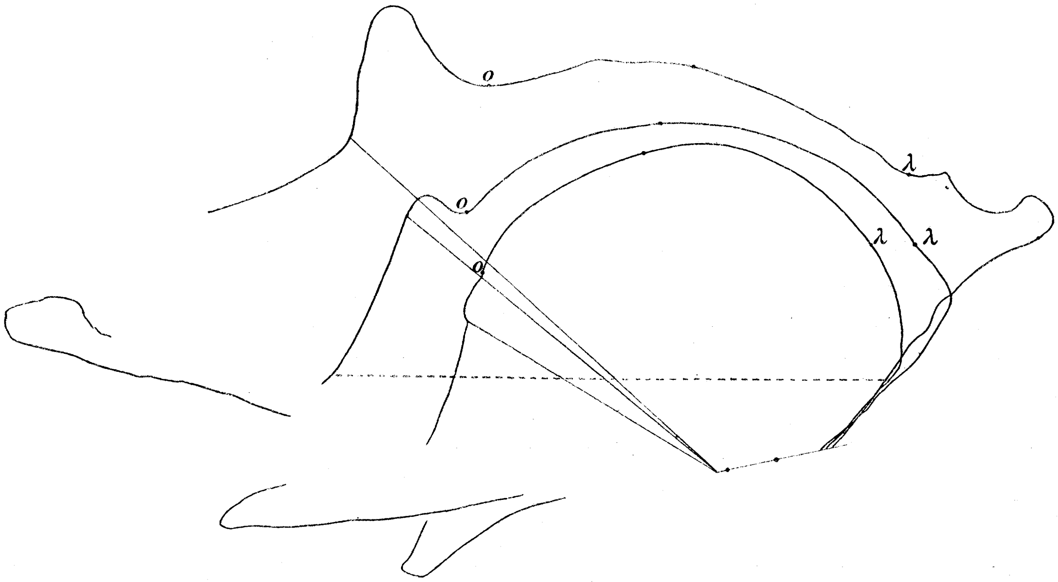

FIG. 11.—Median profiles of three skulls of Gorilla in different stages of growth, superposed on the foraminal axis. The red line is the Frankfort base of the middle profile. ($\times \frac{1}{2}$.)

closed, but only the two large inner incisors of the milk dentition in the upper jaw have made their appearance and the premaxillary suture remains open. The frontal eminences are well marked in both. Five profiles are superposed in fig. 12: measurements gave the following:—

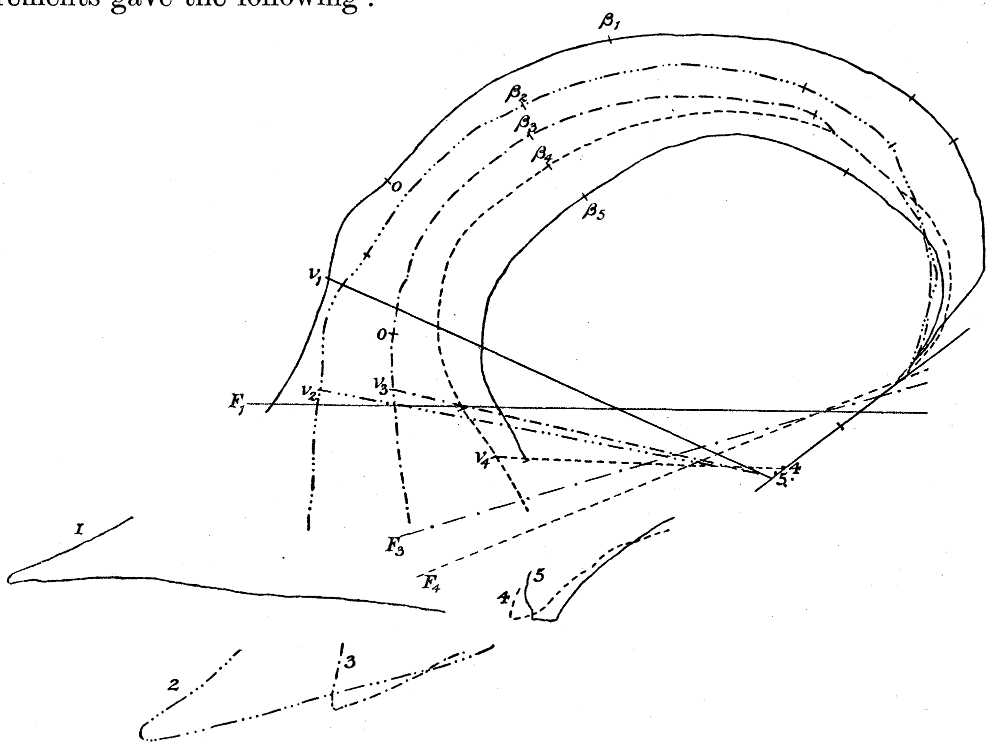

FIG. 12.—Median profiles of five skulls of Orang in different stages of growth, superposed on the foraminal axis. The red lines are the Frankfort lines of the first, third, and fourth profiles. ($\times \frac{2}{3}$.)

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No. of skull	1.	2.	3.	4.	5.	6.	Mean.	Difference between No. 2 and mean.
$b\lambda$ . . .	60	68	73	70	78	75	74·0	6·0
$b\beta$ . . .	67	76	83	83	92	88	76·5	10·5
$bo\phi$ . . .	58	64	81	81	92	92	86·5	22·5

A further consequence might be expected to follow from the mode of growth of the skull: if this has been correctly described, the curvature of the cranial vault should diminish with increasing age, and that it does so is shown by actual measurement. The degree of curvature as expressed by the ratio of the chord and sagitta has been determined in the case of the seven chimpanzees, with the following results:—

No. of skull.	Chord $o\lambda$.	Sagitta.	Ratio.	Chord β. $o\pi$.	Sagitta.	Ratio.
1	98	29	29·6	86	38	44·2
2	101	30	29·7	84	40	47·6
3	102	23	22·5	90	43	47·7
4	97	26	26·8	87	35	41·4
5	101	28	27·7	84	35	41·7
6	109	23	21·1	91	34	37·37
7	105	23	21·9	94	33	35·1

The change in curvature indicated by these measurements is brought about by an adjustment of the relations of the frontal, parietal, and supra-occipital bones to one another rather than by an unbending of the bones themselves: each of the arcs selected for measurement includes a suture through which doubtless the adjustment has been effected.

In the human skull the problem is complicated by the introduction of a new factor, for the brain continues to enlarge with growth from infancy up to a comparatively late period; the face enlarges also but not to such a prodigious extent as in the anthropoid apes. The foramino-basal angle should, therefore, be determined to a large extent by the relative value of these two factors, and no doubt it is. In the accompanying diagram (fig. 13) the cranial profiles of Australian natives in several stages of growth are shown superposed. The smallest represents that of a child one year old; from this stage up to adolescence the growth of the brain has a preponderant effect, and the nasion is carried downwards; subsequently the growth of the face seems to exert a greater influence and the nasion rises upwards.

So far our results are such as accord with the inference drawn from general considerations, but when we return to the question with which we started, that is the cause of the anomalies displayed by the foramino-basal angle of our eight South Australian skulls of adult males, we find that these still remain unexplained.

For if the foramino-basal angle be dependent solely on the relative growth of the brain and face, then some direct relation should exist between the size of the cranium, its index of curvature and the length of the nasi-basal axis. We give the length of the circumference of the calvaria and the index found by dividing this by the maximum length of the skull in the next table, which also includes data in connection with the prognathism of the skulls.

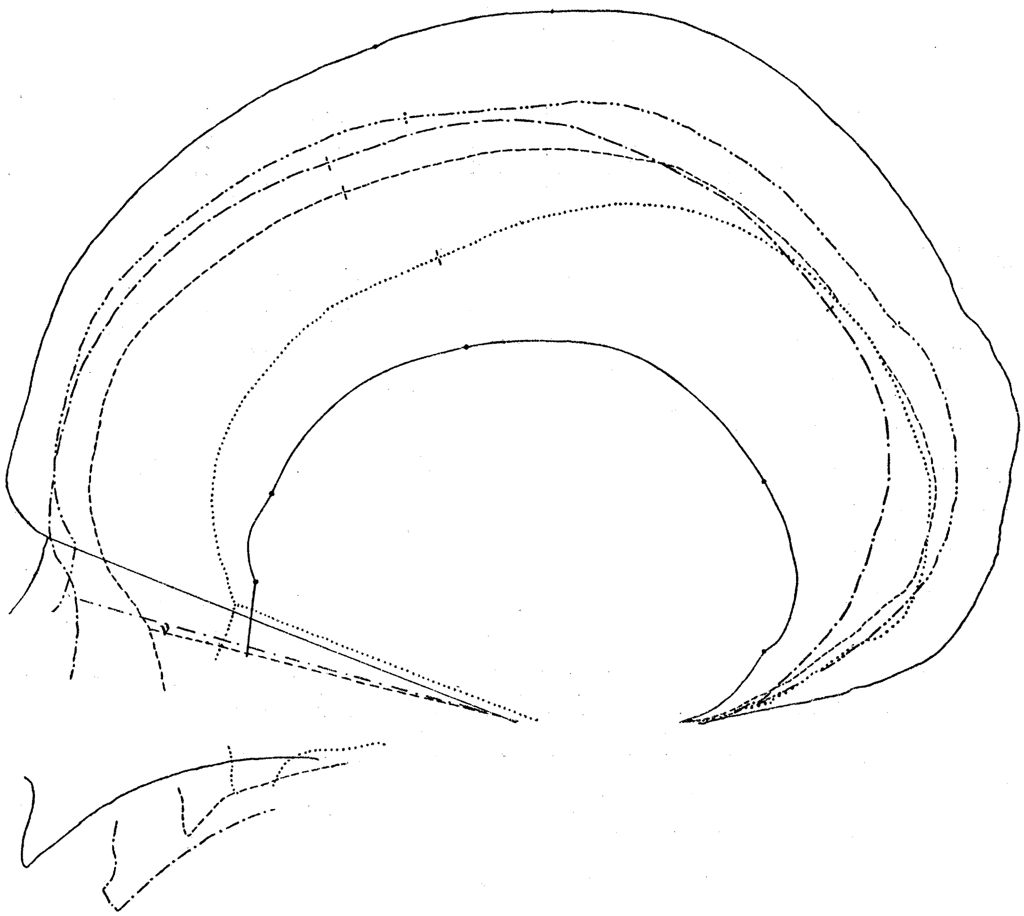

FIG. 13.—Median profiles of six South Australian skulls in different stages of growth, superposed on the foraminal axis. ($\times \frac{2}{3}$.)

It is difficult to discover any relation between these quantities and the magnitude of the foramino-basal angles: Nos. 992 and 994 have each a large index of curvature, but 994 belongs to the group with large foramino-basal angles, and 992 to that with small; Nos. 994 and 998 differ widely in the index of curvature, but both possess large foramino-basal angles. Nor does the ratio of the nasi-basal lines to the index of curvature throw any light on the matter: Nos. 994 and 998 differ greatly in the value of this ratio, in the former it is 177·5 in the latter 145; but both have large foramino-basal angles; 992 and 1001 make a nearer approach in respect to the ratio, which is 169 in the former and 161 in the latter, but one is distinguished by the largest foramino-basal angle observed in the group and the other has a comparatively low angle.

Skull.	Circumference.	Index.	νb.	$pr. b$.	Index.	Frankfort angle.	Angle $\nu . pr. b$.
991	323	169·7	105	101	96·2	85° 0′	69°
992	325	172·0	107	111	103·7	83 0	76
993	305	169·0	105	98	93·3	83 0	65
994	355	177·5	100	102	102·0	80 0	73
995	320	171·0	97	98	101·0	80 0	73
998	295	155·0	106	114	107·5	71 0	79
999	310	162·3	103	103	100·0	76 30	73
1001	317	166·6	99	104	105·5	77 0	77

It would be natural to suspect some connection between the foramino-basal angle and the degree of prognathism exhibited in these skulls, but an examination of the table shows nothing of the kind, or any relation that it does indicate is the reverse of what we might expect; thus No. 998, otherwise very primitive, also presents the largest alveolar index and is one of the two examples in which the Frankfort angle is lowest, yet, as we have seen, it possesses a large foramino-basal angle, while No. 992 unites a large alveolar index with a small foramino-basal angle; on the whole, however, a high degree of prognathism seems to be associated with a large, and a low degree with a small, foramino-basal angle: an astonishing result.

The degree of curvature of the calvarium is very ineffectually expressed, however, by an index and may be better represented by the method of polar co-ordinates: as in the following tables, the first of which gives the angular divergence in degrees of the principal points on the circumference of the sagittal section and the second the length of the corresponding vectors.

Skull.	$o\pi$.	ι.	λ.	β.	o.	γ.	ν.	pr.
991	28·5	62·0	95·0	199·5	268	277	284·5	312
992	30·0	59·0	96·5	197·5	264	274	281·0	306
993	29·0	64·0	100·0	200·0	264	275	280·0	314
994	28·5	57·0	100·0	208·0	272	284	290·0	317
995	31·5	61·5	108·0	214·0	270	282	287·0	314
998	29·0	69·0	99·0	197·0	260	271	277·5	306
999	31·5	65·0	100·5	194·0	263	276	281·5	312
1001	32·5	65·0	105·0	199·0	270	284	286·5	312
Mean	30·0	62·5	100·5	201·0	266	278	283·5	313
Range . . +	1·5	6·5	7·5	13·0	6	6	6·5	4
" . . −	1·5	4·5	4·5	7·0	6	7	6·0	7

Length of Radii.

Skull.	b.	$o\pi$.	ι.	λ.	β.	o.	γ.	ν.	Height.	Altitudinal index.
991	70·0	78	91·0	84·0	70·0	93·5	99·0	96·5	138·5	73·5
992	70·5	82	92·0	83·5	72·0	94·0	100·0	96·0	140·5	74·5
993	70·0	79	100·0	80·0	67·0	90·5	102·0	95·0	137·0	76·0
994	68·0	76	95·0	88·0	73·0	99·0	106·0	101·0	141·0	70·5
995	65·0	73	89·0	82·0	68·0	90·0	99·0	98·0	132·0	70·5
998	61·0	75	82·5	80·0	64·0	94·0	101·0	96·5	123·5	65·0
999	62·0	78	82·0	83·0	65·5	94·0	100·0	96·0	127·0	66·5
1001	60·5	73	92·0	81·0	68·0	95·0	100·5	97·0	126·0	66·5
Mean ...	66·0	77	90·0	82·5	68·0	94·0	101·0	97·0	133·0	70·5
Range +	4·5	5	10·0	1·5	5·0	4·0	5·0	4·0	7·5	5·5
„ −	5·5	4	8·0	2·5	4·0	5·0	2·0	1·0	9·5	5·5

The numbers in the column under ν of the first table give the angular value of the circumference measured from the basion round to the nasal point; and, *ceteris paribus*, the larger this angle the larger should be the foramino-basal; but that this is not the only element which affects the result is shown by the skull No. 998, for its nasion angle is the smallest in the series, while its foramino-basal angle is one of the largest. The nature of the other elements which enter into the problem may be learnt from an inspection of the quadrilateral c, ν, b, $o\pi$ (fig. 14); if the points ν, c, $o\pi$ be taken as fixed, then the magnitude of the foramino-basal angle will depend on the length of the radius cb, that is, on the height of the skull, since cb is a function of the height, approximately one half. The length of the other diagonal $\nu o\pi$ is largely determined by the length of the skull, and thus the magnitude of the foramino-basal angle may be brought into relation with the altitudinal index; this, which is obtained by dividing the height $b\nu$ by the maximum length, is given in the last column of the last table. On reference it will be seen that the correlation we have inferred actually exists; the three skulls with the smallest foramino-basal angles (see table, p. 306) have the highest altitudinal index, and the three with the lowest altitudinal index have the largest foramino-basal angle. The two skulls Nos. 994 and 995 fall nearly into line, but their foramino-basal angles are not so closely approximate as their altitudinal indices: the divergence being due to the fact that the polar angle of the nasion point is greater in 994 than in 995.

As a result of this long discussion, we seem to have elicited the fact that within the limits of the human race the magnitude of the foramino-basal angle stands in no necessary connection with the morphological status. It is determined in the first place by the relative growth of the brain and face, in the next it depends not only on the amount but on the manner of the cerebral increase, so that when the brain is deficient in altitude and a low skull results the foramino-basal angle may be larger than when the brain attains a full and symmetrical development.

The influence of the altitudinal index extends, however, beyond the foramino-basal angle: it affects SCHWALBE'S angle also, the true bregma angle, and indeed all the interior angles of the skull, for these are the angles of a polygon inscribed within the more or less elliptical outline of the sagittal section of the skull; when the minor axis of this is diminished in relation to the major axis, then the interior angles near its extremities are correspondingly increased, while those near the extremities of the major axis are diminished in magnitude. A reference to the table on p. 304 in conjunction with that below will show how the angle $b\nu\beta$ varies inversely with the angle $\nu bo\pi$. SCHWALBE'S angle is thus determined by three factors: the choice of a base, the angular position of the bregma, and the altitudinal index of the skull. All three combine to give it a low value both in the Neandertal group and in the Australian skull No. 998.

Before leaving this subject, we may point out that it is possible to push our analysis of the foramino-basal angle at least one step further. We may conceive the foramino-basal angle as divided into two, $cb\nu$ and $cbo\pi$, by the radius cb. These angles have the following values in the case of our eight Australian skulls:—

Skull.	νcb.	$o\pi cb$.	$\nu bo\pi$.	$cb/co\pi$.	Skull.	νcb.	$o\pi cb$.	$\nu bo\pi$.	$cb/co\pi$.
	°	°	°			°	°	°	
991	64·0	88	152·0	0·8974	995	67·5	86·0	153·5	0·8904
992	61·0	91	152·0	0·8598	998	63·0	99·0	162·0	0·8133
993	61·5	88	149·5	0·8861	999	65·5	96·5	162·0	0·7943
994	71·0	88	159·0	0·8947	1001	69·0	93·0	162·0	0·8288
Mean . .	65·5	91	156·5	0·8581	Range +	5·5	8·0	5·5	0·0393
					,, −	4·5	5·0	7·0	0·0638

The angle $cb\nu$ is determined by the polar angle of ν and the altitudinal index, and it is to this component that the skull No. 994 owes its large foramino-basal angle; but we discover, not without surprise, that in skull No. 998 this same component is comparatively small, 2°·5 indeed below the average, and it is the other component $cbo\pi$ that gives rise to the large foramino-basal angle in this skull and its associates, Nos. 999 and 1001. But the magnitude of the angle $cbo\pi$ depends on the polar angle of $o\pi$ and the relative length of the radii cb, $co\pi$; the polar angle is not of the first importance; a reference to the table will show that in the three skulls with the largest foramino-basal angle it ranges from almost its minimum up to its maximum value; it contributes to the total result a quantity by no means negligible, but small compared to that dependent on the relative length of the radii cb and $co\pi$. This is given in the last column of the last table, and it will be seen that when the angle $o\pi cb$ is large the ratio is correspondingly small. The influence of altitude as represented by cb is still evident even here, but not that of length, for $co\pi$ may also be regarded as a function of altitude measured from behind instead of from in front of the occipital foramen; thus cb and $co\pi$ are both measures of height, the one determined chiefly by the cerebrum, the other by the cerebrum together with the cerebellum.

Thus as a final result of our analysis, founded on actual measurements, we find that the magnitude of the foramino-basal angle is determined by five several variables, the polar angles of ν and $o\pi$ and the length of the radii $co\pi$, cb, and $c\nu$.

The Glabella.—

Number.	Pars glabellaris.	Pars cerebralis.	Index.	$\gamma\iota-\nu\iota$.	$\gamma\iota-o\iota$.
991	26	96·0	27·1	5	2·5
992	28	94·0	29·1	8	2·0
993	28	86·0	32·6	6	2·5
994	32	94·0	34·0	10	5·5
995	28	82·0	34·1	8	3·0
998	30	96·0	31·3	6	4·0
999	31	92·5	33·5	8	2·0
1001	28	94·0	29·8	7	1·0

The mean index is 31·1, with a variation of + 2·9 and − 4. In the Neandertal group the mean index is 40·8, with a variation of + 3·4 in the Neandertal calotte and − 6·4 in Spy II.

Prognathism.—The doubts sometimes expressed as to the value of this character are probably due to the fact that attention has often been directed too exclusively to its angular measurement, an element which requires to be supplemented by a linear quantity, such as the alveolar index or the length of the face, to give a complete account of the projection of the upper jaw. To secure consistency in nomenclature it would be well to restrict the term "orthognathous" to those few skulls which really are so, and to regard all others as prognathous. The prognathism may be most simply measured by two factors: first the divergence of the angle made by the nasi-prosthenion line with the Frankfort line from a right angle, *i.e.*, the complement of the Frankfort angle, and next by the length of the intercept made on the line $pr.\ a$ parallel to the Frankfort line by the nasi-prosthenion line and the perpendicular dropped on to $pr.\ a$ from the nasion.

The relation of the prosthenion to the other points on the sagittal section is most clearly expressed by the system of polar co-ordinates, and the prognathism may be most simply measured on this system by drawing a line parallel to the initial line (cb) through the nasion and dropping a perpendicular from the prosthenion to intersect it at a point a (fig. 14); the angle $pr.\nu a$, which is the angle made by the line $pr.\ \nu$ with the initial line, represents the angular, and the length $pr.\ a$ the linear

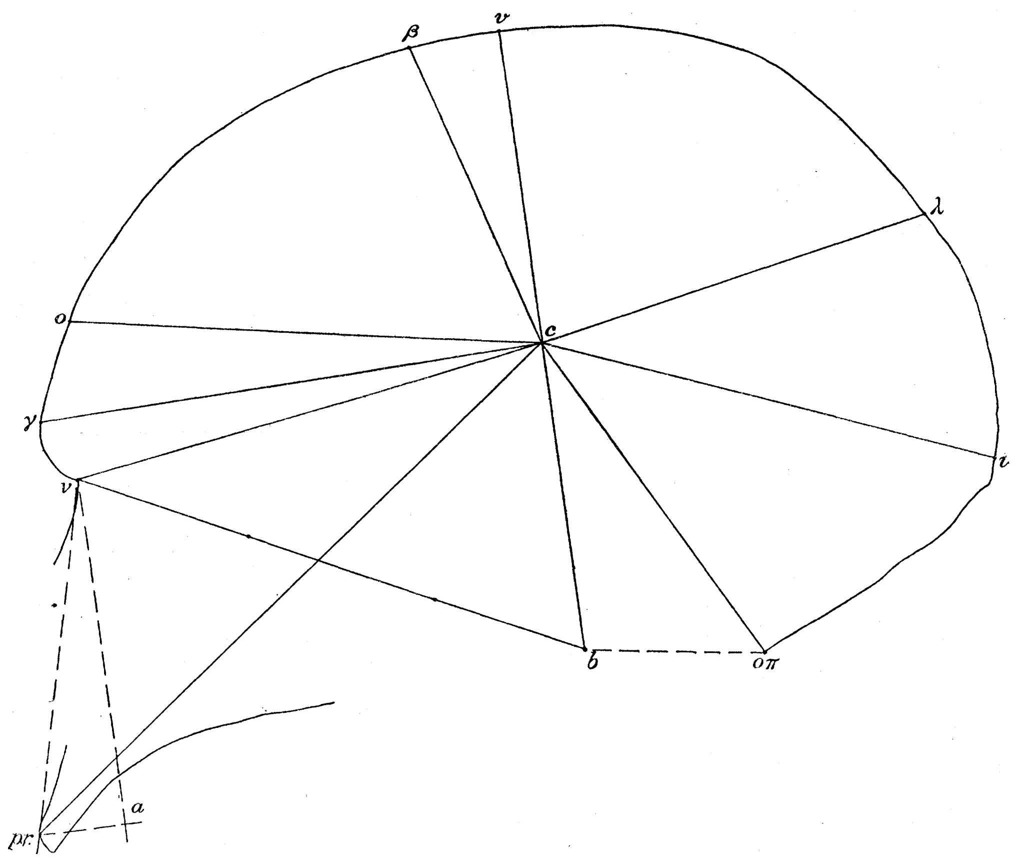

FIG. 14.—Median profile of South Australian skull (No. 998), to illustrate the nature of the foramino-basal angle and the amount of prognathism. $(\times \frac{2}{3}.)$

amount of projection of the jaw. In the following table the prognathism of our South Australian skulls is expressed, with respect to the Frankfort line, in the second two columns, and in the first two by the method just described, which only differs from the preceding by the substitution of a line parallel to the vector of 90° for the Frankfort line :—

Skull.	*pr. a.*	*pr. va.*	Frankfort.		Skull.	*pr. a.*	*pr. va.*	Frankfort.	
			pr. a'.	*pr. va'.*				*pr. a.*	*pr. va'.*
		°		°			°		°
991	6·5	5	6·5	5·0	995	6·0	6	12·0	10·0
992	17·0	16	14·0	7·0	998	18·0	14	24·0	19·0
993	3·5	2	9·0	7·0	999	8·0	7	15·0	13·5
994	2·0	2	12·0	10·0	1001	6·0	6	15·0	13·0
Mean . .	8·5	7	13·5	10·5	Range . −	6·5	5	6·5	5·5
Range . +	8·5	9	10·5	8·5	English . .	1·0	1	3·0	3·0

The usual measurements for prognathism are given in the table on p. 312. The mean of the Frankfort angle obtained from them is a little above 79°, the range is +6° and −8°. The mean of the alveolar index is 101·5, the range +14·2 and −8·2. The most prognathous skull of the series is No. 998; its pre-eminence in this respect is especially marked in measurements made upon the Frankfort base.

Measurements of the prognathism of an average English skull have been added to the preceding table for comparison.

It may be of interest to note that there appears to be absolutely no connection between the prognathism and the capacity of these skulls; No. 994, with the highest capacity, certainly presents a very trifling amount of prognathism, but No. 993 scarcely more, although its capacity is the smallest of the series.

The Weight and Thickness of the Skull.—The weight of the skull is a character of some importance, inasmuch as it indicates roughly the thickness of the cranial wall, and this cannot altogether be disregarded in the consideration of characters derived from external measurement.

As an illustration, in itself of interest, we may compare the skull of a male Australian aborigine, No. 972, from Queensland, with that of an average Englishman. Their profiles are superposed (fig. 15), the nasi-basal line being taken for

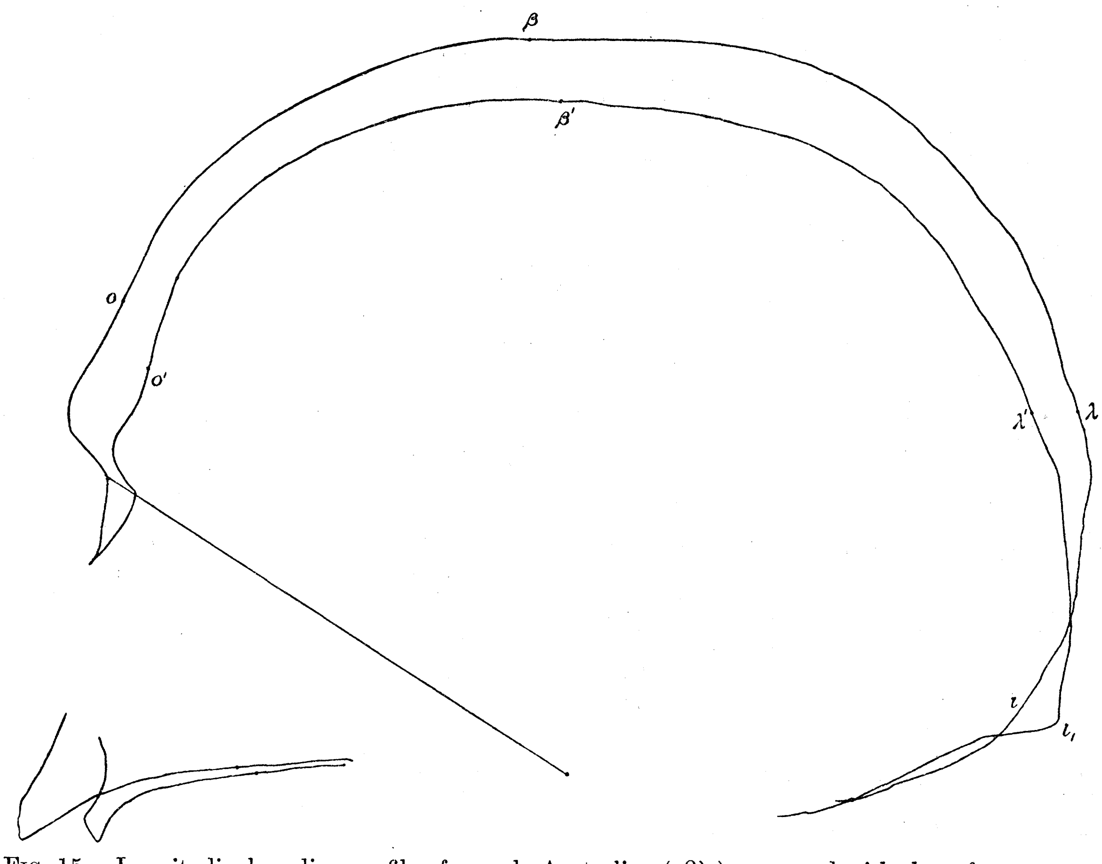

FIG. 15.—Longitudinal median profile of a male Australian ($o\beta\lambda\iota$) compared with that of an average Englishman ($o'\beta'\lambda'\iota_{,}$) by superposition on the nasi-basal line. ($\times \frac{2}{3}$.)

a base because the opisthion is missing from the Australian skull, a small fragment of the occipital bone having been broken off. It will be seen that the profile of the English skull lies far within that of the Australian for nearly the whole of its course. This somewhat surprising observation led me to determine their capacity; it was found to be almost the same in both: 1585 cub. centims. in the English and 1570 cub. centims. in the Australian skull, the English thus being slightly the greater. The weight of the Australian skull is now 1074·5 grammes, and must have been a little more when complete; that of the English skull is only 438·5 grammes.

The weight divided by the capacity gives an index which would afford a surer means of comparison were it not for disturbing elements, such as the differing density of the bone and the unequal development of the face. In the English skull under consideration the index is 28, or 16 below the average, in the Australian it is 68, or 24 above the average.

A rough estimate of the thickness of the skull may be made by assuming the form of the cranium to be an ellipsoid, with the maximum length, breadth, and height as axes. If these be shortened, not proportionately, but by equal decrements, till the volume of the resulting ellipsoid is equal to that of the measured capacity of the skull, then the difference in length between the axes so obtained and those of the original ellipsoid will represent twice the mean thickness of the wall of the skull. Applied to the two skulls above, this method gives a thickness of 3·5 millims. for the English skull and 7·6 millims. for the Australian; a difference consistent with their respective weights, and with the difference in diameters of their profiles. A comparison may easily be made by reference to fig. 15, for since the capacity of the two skulls is about the same and their profiles are superposed on a common base, the inner surfaces of the two should be coincident along a line 15·2 millims. within the profile of the larger skull and 7 millims. within that of the smaller one. Allowing for difference in form, this is approximately the case.

In the following table the index of weight and estimated thickness are given for the eight Australian skulls under description:—

Number.	Weight.	Index.	Thickness.	Number.	Weight.	Index.	Thickness.
991	735	56·8	7·8	995	569	57·98	8·0
992	683	49·7	7·0	998	693	58·3	6·5
993	683	58·4	7·3	999	646	49·3	7·0
994	695	47·6	7·5	1001	661	52·5	6·2

Direct measurements made on Skull No. 998, which Professor BOURNE has been kind enough to have bisected for me, give an average of 6·7 millims. taken from 26 observations made along the median line at intervals of a little more than 10°; over other regions the thickness of the wall varies greatly, and the labour of determining a true average would be incommensurate with the value of the result. In the case of bisected skulls it would be simpler to make our comparison near some standard point. ANDERSON* gives measurements of the thickness of 185 British skulls, taken in each case at 12 different points; to obtain a true average it would be necessary to know the mean thickness of given areas; in default of this information I have simply added the results given by ANDERSON for each point and divided by the total number of observations: in this way an average of 13·75 sixty-fourths of an inch, or 5·12 millims., is obtained, and this is very nearly the thickness of the parietal bone a little behind the bregma. In Skull No. 998 it varies from 5·5 to 6·5 millims. in this region. Other Australian skulls give slightly different results, varying from 6 to 8 millims. The Australian skull is thus distinctly of greater thickness than the European, but not by much more than 1 or 2 millims.

Female Skulls.

A brief description may be given to the three women's skulls. Measurements of their more important characters are given in the three following tables:—

Skull.	Cap.	Wt.	Lt.	Br.	Index.	Ht.	A. index.	γ index.
997	1135	504	175	123	70·3	125	71·3	32·1
1000	1100	561	177	125	70·6	122	68·9	34·7
1002	1185	600	179	125	69·8	121	67·5	34·9

Note.—Cap., capacity; Wt., weight; Lt., length; Br., breadth; Index, cephalic index; Ht., height; A. index, altitudinal index; γ index, glabellar index.

Table of Polar Co-ordinates.

Skull.	οπ.	ι.	λ.	β.	ν.	pr.	b.	οπ.	ι.	λ.	β.	ν.	pr.
	°	°	°	°	°	°							
997	29·5	64	105	204	286	317	62	74	83	77	64	93	135
1000	31·5	69	106	205	287	316	60	73	82	79	64	93	132
1002	26·5	66	104	204	292	319	59	71	84	79	64	112	131
Mean ♀ .	29·0	66	105	204	288	317	60	73	83	78	64	99	133
,, ♂ .	30·0	63	101	201	284	312	66	77	90	83	68	94	135

* *Loc. cit.*

Prognathism and Foramino-basal Angle.

Skull.	*vboπ*.	*vb*.	*pr. b*.	Index.	*Fk*.	*Fk. c*.	*Fk. a*.	*pr. va*.	*pr. a*.
997 . . .	161°·5	91·0	99	108·8	77°	13°	16	3°	3
1000 . . .	163·0	94·5	98	103·7	78	12	14	3	3
1002 . . .	171·0	91·0	94	103·0	78	12	13	−2	−2
Mean ♀ . . .	165·0	92·0	97	105·0	78	12	14	1	1
„ ♂ . . .	156·5	103·0	104	101·0	79	11	14	7	9

Note.—*vboπ*, foramino-basal angle; *vb*, nasi-basal line; *pr. b.*, prosthenion-basal line; index, alveolar index; *Fk.*, Frankfort angle; *Fk. c.*, complement of Frankfort angle; *Fk. a.*, projection of prosthenion (as defined on p. 315); *pr. va*, angle made by line *pr.* with the initial line; *pr. a*, projection of *pr.* (as defined on page 315).

A singular uniformity characterises these skulls: particularly noteworthy are the small capacity, the low altitudinal index, the large index of the glabella, notwithstanding the low relief of this feature, the uniform prognathism, slightly greater

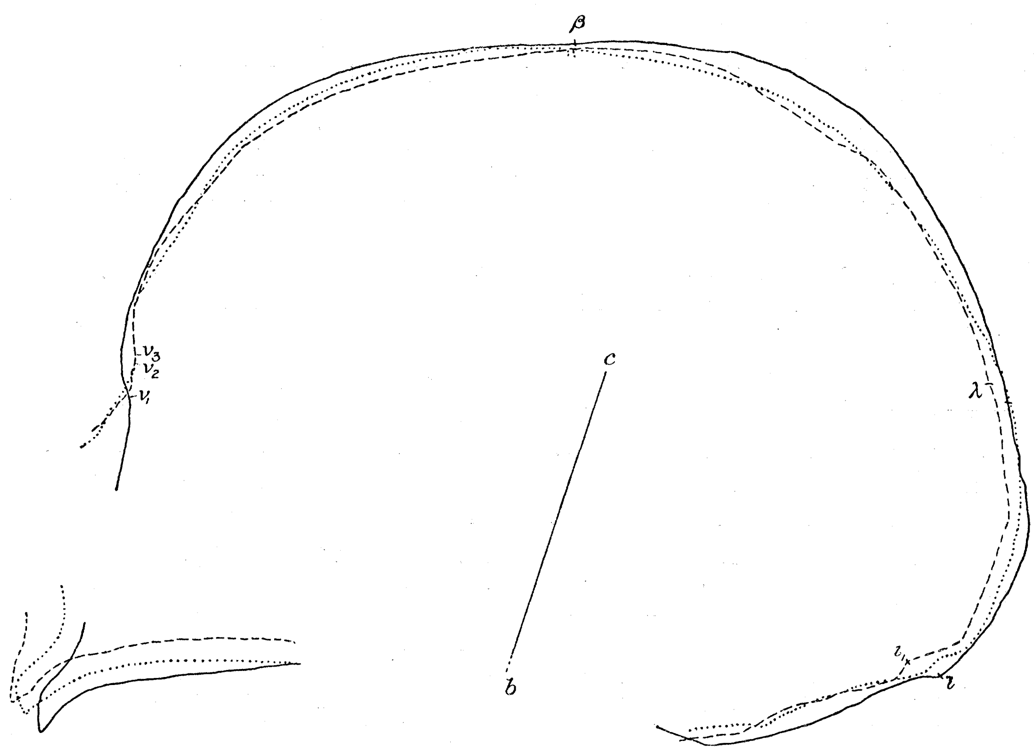

FIG. 16.—Longitudinal median profiles of the skulls of three South Australian women, superposed on the centro-basal (*cb*) or initial line. ($\times \frac{2}{3}$.)

than the average of the male skulls, the angular rotation forwards of all the important features except the opisthion, and the remarkable magnitude of the foramino-basal angle. The last-named feature is more than 8° above the average of the male skulls, and 3° above the maximum. All the three quantities which

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determine this angle—*i.e.*, the altitude of the skull, the polar angle of the nasion and the ratio of the opisthion radius to the basion radius, conspire to give it a high value in the female skull. This will be seen from the following table :—

Skull.	*vbc.*	*oπbc.*	*bc/oπc.*
997	78·0	97·0	0·805
1000	70·0	93·0	0·822
1002	68·0	93·5	0·831
Mean ♀	72·0	94·5	0·819
„ ♂	65·5	91·0	0·858 (see p. 314)

THE GIBRALTAR SKULL (Plate 29).

The first to include this skull in the Neandertal series were QUATREFAGES and HAMY,* but for a more complete identification we are indebted to SCHWALBE,† who has pointed out a remarkable correspondence between many of its more important features and those of the Neandertal calotte. The frontal torus, which so far has proved a most trustworthy guide, is plainly of the Neandertal type, differing solely in the less impressed character of the associated transverse fossa.

If this identification be accepted, and after a careful examination I, for my part, see no reason to dispute it, then the Gibraltar skull acquires a unique interest as the only example of its kind which retains in unbroken and undisturbed connection the bones of the face and the basi-cranial axis. A detailed description is consequently imperative, and I trust it may be undertaken by a more competent anatomist ; in the following account I can only treat of the more salient points.

The skull was excavated from a brecciated talus in quarrying operations behind "Forbes' Battery" under the north front of the Rock of Gibraltar. It was obtained by Mr. BUSK, and exhibited before the Anthropological Congress at its meeting in Norwich, 1868, where it came under the notice of HUXLEY who, in calling attention to its primitive character, pointed out as a simian feature the absence of the canine fossa, which is replaced by a convex surface.

BROCA,‡ who records HUXLEY'S observations, has himself given a short account of the skull, based on photographs. He calls attention to the great width of the orbits (" 44 millims."), broader than any he had encountered in any human skull, not excluding even that of the " vieillard des Eyzies." In the last named the excessive breadth is said to be compensated by deficient height, while in the Gibraltar skull

* QUATREFAGES and HAMY, 'Crania Ethnica,' 1882, p. 21, figs. 18 and 19 after BROCA.

† G. SCHWALBE, 'Studien zur Vorgeschichte des Menschen,' *tom. cit.*, p. 154, 1906.

‡ BROCA, "Crânes et Ossements humains des Cavernes de Gibraltar," 'Bull. Soc. d'Anthrop.,' 1869 vol. 6, p. 146.

the height of the orbits is exaggerated, giving to the index a value of 88·83. The inter-orbital space is very broad, 23 millims. below and more above. The temporal region is said to be masked by the exterior border of the orbits.

A reference to the skull, accompanied by two illustrations reduced from photographs, showing the front and side view, occurs in a report of the Hunterian oration delivered by N. C. MACNAMARA in 1901.

These observations, sufficiently scanty if we except SCHWALBE's last contribution, are all that I can discover in connection with a cranium which completes our knowledge of the Neandertal skull to a very remarkable degree.

The skull is in a good state of preservation, though far from complete, and has been extricated from its matrix of hard sandstone with great care and skill. It lacks a large part of the sinciput and a good deal of the left side. The lambdoidal suture is plainly marked, but the lambda is missing, the supra-occipital, though nearly entire, being broken off just behind the place where this point should have been situated. The occipital tori and the inion are preserved, but the opisthion has disappeared. The greater part of the frontal bone is intact, but the left side has been carried away by a fracture, which crosses the middle line in front of the coronal suture, so that the bregma is absent. The anterior and middle region of the cranial base shares in this odd mixture of good and evil fortune; the greater part is well preserved and clearly displayed; and it is solidly connected without any intervening fracture with the adjoining parts of the skull; on the other hand a small fragment has disappeared from its posterior extremity, carrying away with it the basion.

We may begin our description with the calvarium proper, the profile of which is given in fig. 17; its maximum length is 190 millims., measured from the glabella to a point 20 millims. above the inion; its breadth is uncertain, owing to the defect in the left side of the skull, but cannot have been far from 144 millims. as stated by SCHWALBE. The cephalic index is consequently close upon 80. The height cannot be ascertained precisely owing to the absence of the sinciput, but it can scarcely have been less than 117 millims.; the same defect excludes a direct measurement of the calottal height, which may be estimated as between 82 and 87 millims.

The general attitude of the skull is given by the Frankfort line, which makes an angle of 17° with that drawn from the glabella to the inion (fig. 17 and fig. 25, p. 336); this shows how misleading is the use of the latter as a horizontal base.

The frontal torus is large but somewhat less prominent than in other members of the Neandertal group, and, as already remarked, the supra-toral fossa is unusually shallow for a skull of this type. Such differences may possibly be connected with a difference of sex. Measurements of the glabellar region are given on p. 284.

The frontal angle of SCHWALBE measures between 71° and 72°, and is thus almost identical with that of the Australian skull No. 998 (see p. 287). Since the absence of the bregma and lambda renders it impossible to obtain SCHWALBE's angle (50°?),

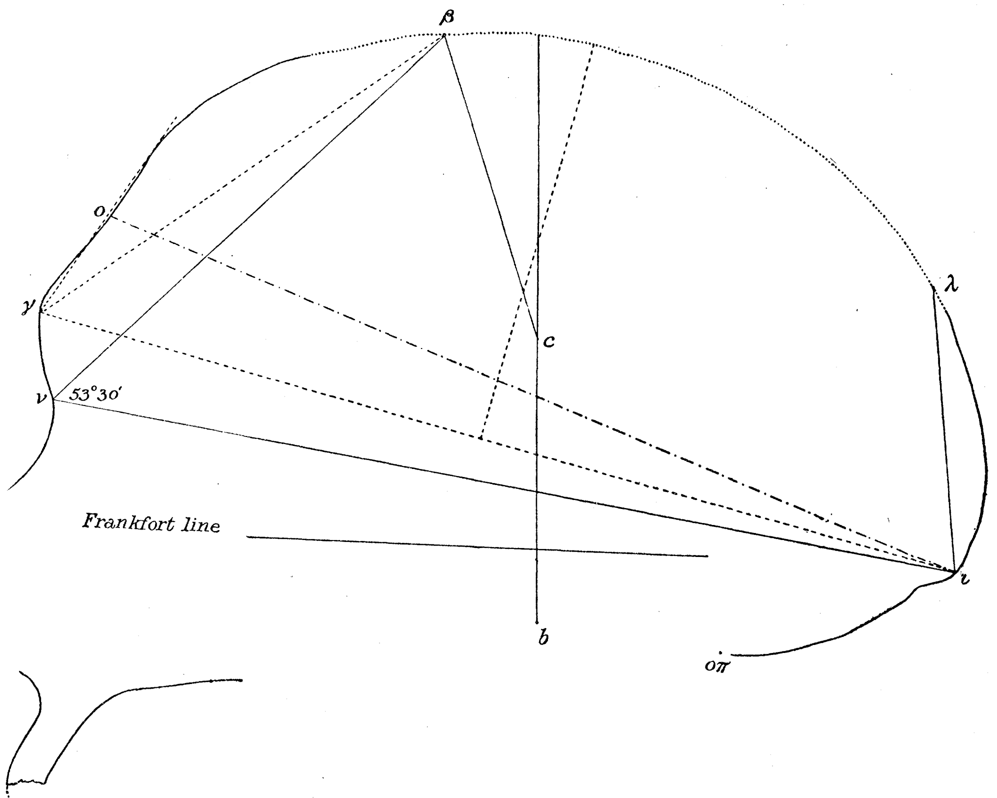

FIG. 17.—Median profile of the Gibraltar skull. (× ⅔.)

and the superior inial angle (75 ?), we shall adopt for the further comparison of these skulls the method of polar co-ordinates (fig. 18).

As affording the requisite data for reducing our results to those of BROCA's system, it may be stated that the centre of the auditory meatus in the Gibraltar skull is situated on the basion radius, 42 millims. from the centre of figure, and 13 millims. from the basion; in the Australian skull No. 998 it is similarly situated, *i.e.*, on the basion radius, but at a distance of 45 millims. from the centre, and 17 millims. from the basion.

In the following table angular measurements are given in the two lines above, and linear, in millimetres, in the two below; the symbol "*fr.*" refers to the fractures crossing the profile of the Gibraltar skull, and the corresponding points in the Australian No. 998 :—

Skull.	οπ.	*fr.*	ι.	*fr.*	λ.	β.	*fr.*	o.	γ.	ν.	*pr.*	*b.*
	°	°	°	°	°	°	°	°	°	°	°	°
Gibraltar . .	31 ?	35	61	95	98 ?	197 ?	219	254	268	277·5	311	360
998 . . .	28	35	69	95	101	197	219	260	271	278·0	306	360
	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
Gibraltar . .	73 ?	74	94	81	81 ?	65 ?	72	88	99	97·0	140	56 ?
998 . . .	76	77	93	82	80	64	68	94	102	97·0	140	62

The probable position of the bregma, lambda, and opisthion points was estimated after a general consideration of the evidence, before the determination of their polar co-ordinates was taken in hand, and thus their approximate correspondence with the

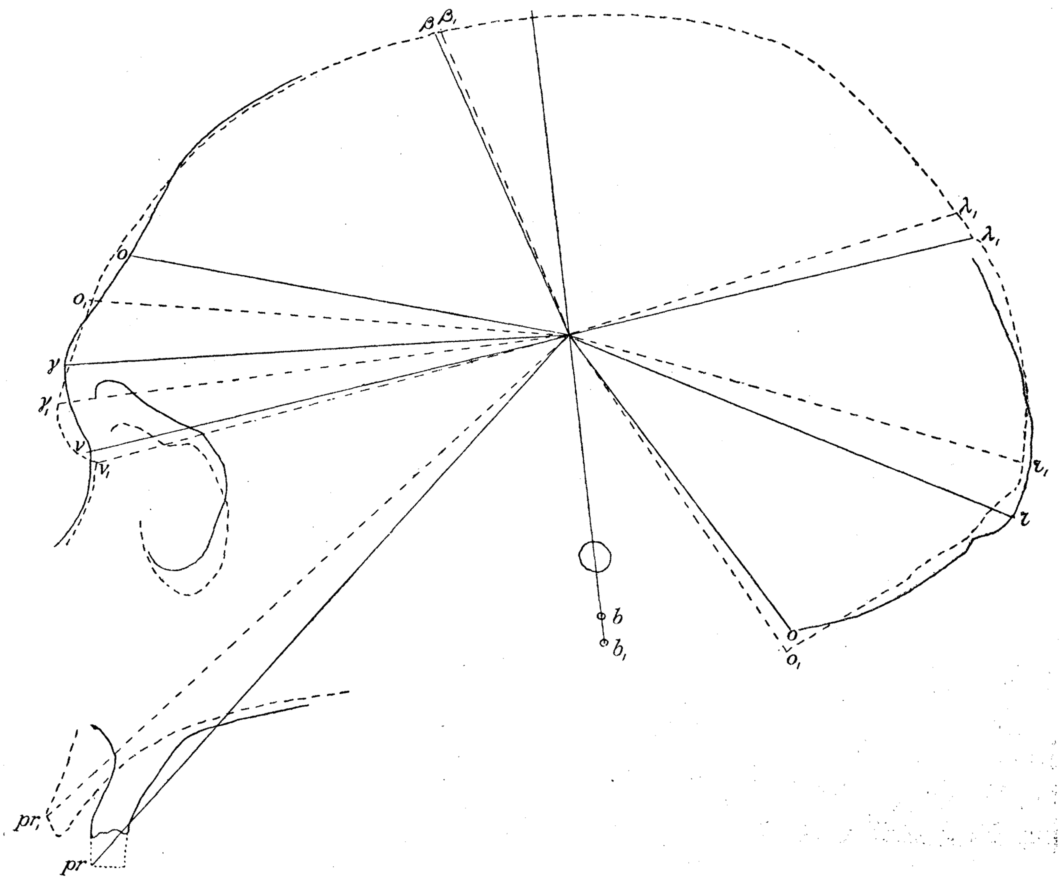

FIG. 18.—Median profile of the Gibraltar skull (continuous line) compared with that of the South Australian skull, No. 998 (broken line) by superposition on the initial line. $(\times \frac{2}{3}.)$

similar points in the Australian skull becomes all the more striking. The widest divergence is to be found in the position of the inion, which lies 8° nearer the initial line in the Gibraltar skull, and in this respect as well as in its situation below the extremity of the maximum diameter of the skull the inion makes a marked departure from the Neandertal type. In the absence of the basion we might have taken some other anatomical point, such as the nasion, to determine the initial line; but since the nasion points in both the Gibraltar and the Australian skull are practically coincident, as measured on the present scheme, nothing would have been gained by such a substitution. The length of the nasion radius is the same in both skulls, but the ophryon radius of the Gibraltar skull is shorter than that of the Australian by 6 millims., and the glabella radius by half this amount.

The horizontal outline of the skull taken through the glabella parallel to the Frankfort line is shown for the right side in fig. 19, the corresponding outline of the

Australian No. 998 being added for comparison. The greater breadth of the Gibraltar skull is especially obvious in the parietal region.

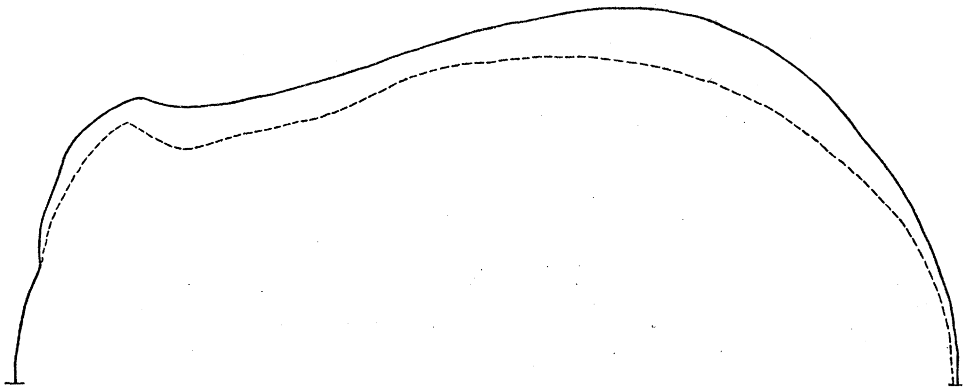

FIG. 19.—Horizontal outline of the right side of the Gibraltar skull (continuous line) drawn through the glabella parallel with the Frankfort line, compared with a similar outline of the South Australian skull, No. 998 (broken line). ($\times \frac{2}{3}$.)

The Basi-cranial Axis.—The vacuity on the left side of the skull affords an excellent opportunity for obtaining a profile of the *basis cranii* by means of the haptograph (fig. 20.) On each side of the strongly marked frontal crest the bone is

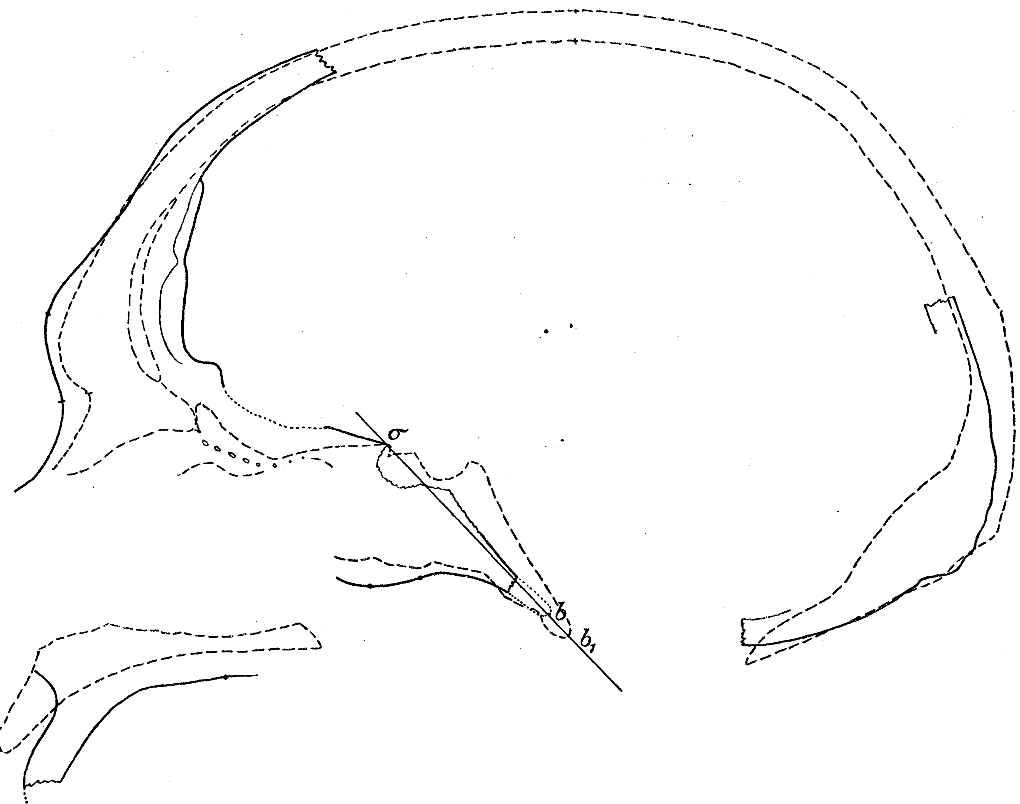

FIG. 20.—Sagittal section through the Gibraltar skull (continuous line) compared with a similar section through the South Australian skull (No. 998), by superposition on the middle basi-cranial axis. ($\times \frac{2}{3}$.) σ, *limbus sphenoidalis*.

deeply pitted with meningeal depressions. The *crista galli* is intact, and its apex is situated 66 millims. from the centre of figure, at an angle of 277°. The cribriform plate is incrusted with a thin layer of foreign material.

The greater part of the *jugum sphenoidale* and anterior clinoid process is exposed, and the *limbus* affords a well defined feature. The *sulcus opticus* is filled with sandstone, as is the pituitary fossa; the *dorsum sellæ* is broken off, as is shown by the spongy texture of the bone exposed at the surface, but the greater part of the *clivus* retaining its natural surface is preserved, as far as the fracture which has carried away the basion.

On the under side of the skull the base is also exposed, and, retaining a good deal of its natural surface, extends up to and a little beyond the vomerine point; a mass of calcareous sandstone then succeeds, in which sections of the *lamina perpendicularis* appear at intervals. The under surface of the base is remarkably horizontal, and the vomerine point lies a little below the nasi-basal line, while in all Australian skulls which I have examined it is situated a little above this line.

Measurements relating to the base are given in the following table :—

	cr.	σ.	*cr.*	σ.	$o\pi. b. \sigma.$	$b. \sigma. \nu.$	$b. \sigma. cr.$
	°	°	mm.	mm.	°	°	°
Gibraltar . . .	277·0	305	66	39	148	140	156·5
998	281·5	304	76	44	144	144	140·0

The numbers in the first four columns refer to polar co-ordinates; in the remaining columns, to angles measured from a basi-cranial axis ($b\sigma$). *cr.* stands for *crista galli* and σ for the *limbus sphenoidalis.*

It will be seen from the radial angles that the anterior part of the base, as represented by the *crista galli,* has undergone less rotation forwards in the Gibraltar than in the Australian skull No. 998; at the same time, as shown by the length of the radii, the anterior extremity of the axis is tilted upwards through a larger angle in the Gibraltar skull, so that the *crista* lies 10 millims. nearer the centre than in the Australian example.

Turning next to the figures in the last three columns, we perceive that the foramino-basal angle, as measured from the line $b\sigma$, is greater in the Gibraltar than in the Australian skull, 148° as against 144°, and thus makes a nearer approach to that met with in the higher races, such as Europeans; but we have already seen how deceptive this character may be, and there can be little doubt that in this case, as in that of the Australian skulls already so fully discussed, the magnitude of the foramino-basal angle stands in direct relation to the flattened form of the cranium.

The sphen-ethmoidal angle, measured in the absence of the prosphenion and ephippum, from the line $b\sigma$, is found to be somewhat smaller in the Gibraltar than in the Australian skull No. 998, and thus we are again confronted with an anomaly, for a decrement in this angle is supposed to stand in connection with a higher morphological status. It would be little less than astonishing if this were so in the case under consideration, most of the other available evidence pointing in the opposite direction. The difficulty arises, as I believe, from an unfortunate method of comparison. It is by no means clear, for instance, why the nasion should be chosen to determine the angular movement of the anterior extremity of the axis; the nasion is far from being a fixed point, and it does not form part of the axis. The *crista galli* seems to offer many advantages as a substitute, especially in the present case, where it is one of the few points perfectly preserved; it has about the same dimensions, including height, as in the Australian skull No. 998, and may therefore be employed as a means of comparison, without introducing fresh sources of error (fig. 21).

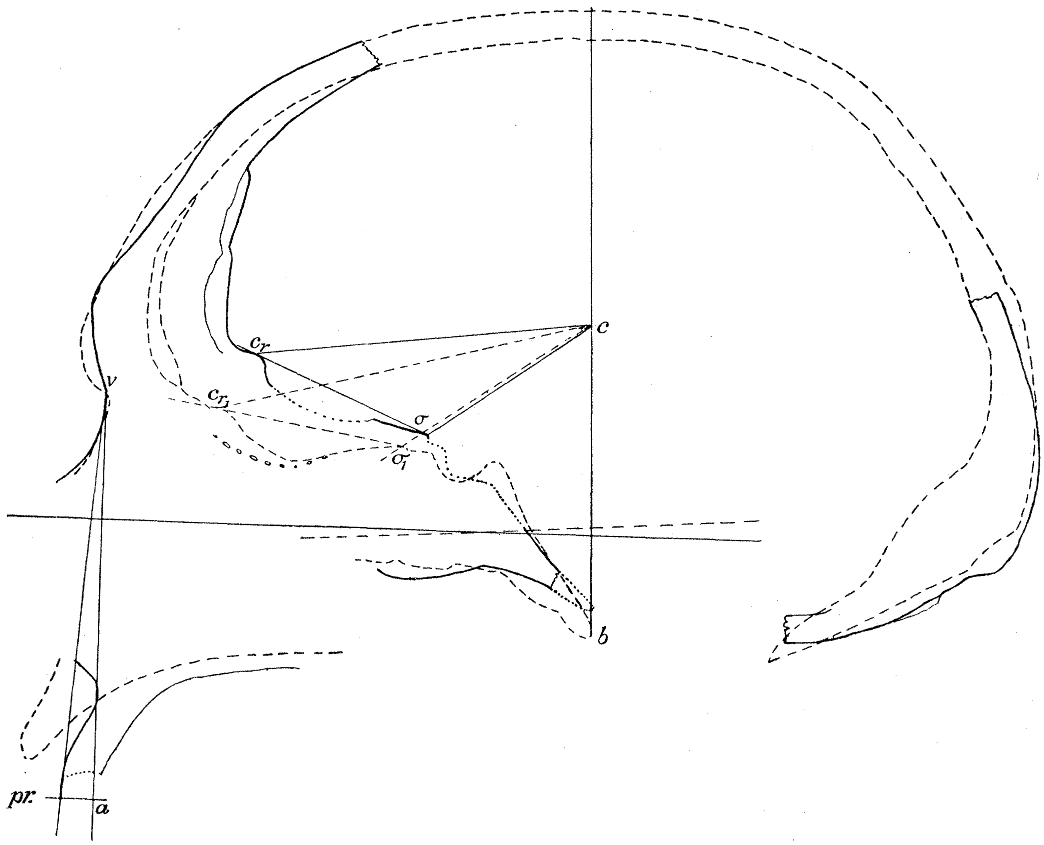

FIG. 21.—Sagittal sections of the Gibraltar skull (continuous line) and the South Australian (No. 998) superposed on the initial line. ($\times \frac{2}{3}$.)

The new sphen-ethmoidal angle, included between the axes $b\sigma$ and $cr.\,\sigma$, is now found to be such as we might expect, that of the Gibraltar skull being no longer less, but greater, than that of the Australian, and this to the extent of 16° 30′. The sphen-ethmoidal angle thus considered affords, perhaps, the most marked sign of morphological inferiority that we have as yet encountered in this skull.

It is of interest to observe that KRAMBERGER has discovered a peculiarity in the slope of the cribriform plate in the Krapina remains.* As to its precise nature there is some difficulty in forming an opinion, owing to the fragmentary condition of the bones accessible to study; but KRAMBERGER himself seems to think that the *crista* was rotated further downwards than in the higher races, and that this displacement resulted from a supposed descent of the nasion, due to the exercise of the more powerful temporal muscles which are hypothetically ascribed to the Neandertal race. No suggestion of this unusual muscular development is afforded, however, by the Gibraltar skull. The temporal lines are by no means strongly marked, and do not extend so far on to the cranium as in the Australian skull. We have already alluded to the remote possibility that the Gibraltar skull belonged to a woman; special importance, therefore, attaches to SCHWALBE'S observation that the temporal lines present no unusually close approximation either in the Neandertal skull or in the two skulls from Spy.†

A second remarkable character of the Gibraltar skull is to be found in the thickness of the frontal bone immediately in front of the *crista*; measured from the frontal crest this amounts to 28 millims., and from the general surface adjacent to 24 millims.; at the ophryon this has diminished to 14 millims., and near the broken edge in which the bone terminates to 7 millims. A similar thickness has been recorded by KRAMBERGER in the case of two fragments of frontal bones found at Krapina, one of them measures 25·2 millims. across, "near the zygomatic suture," the other 25·4 millims.; the minimum thickness near the edge is 9 millims. in the one case and 10·6 millims. in the other.

In the Australian skull, No. 998, the maximum distance from the frontal crest to the surface of the glabella amounts to 16 millims., and from the base of the crest to 13 millims. Closely approximate measurements were obtained from two other Australian skulls which have been bisected. TOPINARD cites measurements‡ by MANOUVRIER which gave 13 millims. as the thickness of the frontal bone behind the glabella in the case of 14 male skulls, and 8 millims. in eight female skulls, and by WOLKOFF on 73 male skulls, which gave a mean of 12–13 millims. and a maximum of 24–25 millims. No information is given as to the races represented by these skulls, but in the maximum found by WOLKOFF we have another illustration of the fact that primitive characters which were at one time characteristic of the species now only survive in exceptional individuals.

Since the external length is identical in the Gibraltar skull and the Australian, No. 998, and the occipital bone is of about the same thickness in each, it follows that the internal length must be more than 10 millims. less in the former, and

* K. GORJANOVIĆ KRAMBERGER, "Der paläolithische Mensch und seine Zeitgenossen aus dem Diluvium von Krapina in Kroatia," 'Mitth. Anthrop. Gesell. Wien,' 1905, vol. 35, p. 204, fig. 3.

† SCHWALBE, "Der Neandertalschädel," *loc. cit.*, p. 19; FRAIPONT and LOHEST, "La race humaine de Neanderthal, etc.," *loc. cit.*

‡ TOPINARD, 'Éléments d'Anthropologie,' p. 658.

it seems natural to connect this deficiency with a shortening of the frontal lobes, a view which is sustained by the approximate correspondence in position of the bregma, pituitary fossa, and the alæ minoræ of the sphenoid in the two skulls, for this indicates that the origin of the frontal lobes has not been shifted backwards in compensation for their abbreviation in front. Compensation has been effected, however, in another way, *i.e.*, by the broadening of the skull, for the Gibraltar skull is 10 millims. wider than the Australian in the temporal and frontal region.

The exterior of the supra-occipital bone presents a strongly marked ridge in the region where a sudden change of curvature distinguishes the upper limb of this bone from the lower; this ridge represents the confluent occipital tori, its middle part is the inion.

The internal surface of the supra-occipital is deeply impressed by the posterior lobes of the cerebrum, the deepest part of the concavities originally occupied by them lying at about the level of the occipital tori, so that the internal inion is situated more than 10 millims. below the external inion.

The lambdoidal suture presents rounded lobes with crenulate margins, and is somewhat more complicated than that of the Neandertal calotte. The lambda was situated in the middle of a projecting lobe, on each side of which is a deep retreating saddle. In front of the saddle on the right side is a second suture, convex forwards, apparently indicating a Wormian bone.

The thickness of the supra-occipital near the lambda is 7 millims.

The Cranial Capacity.—An attempt was made to estimate the capacity of the cranium. The right side is sufficiently complete for restoration within narrow limits of error; this was accomplished by moulding a sheet of plasticine to fill the vacuities. A median circumferential line was then drawn to divide the cranial cavity into a right and left moiety. The capacity of the right moiety was measured with millet seed according to FLOWER'S method, and found to amount to 630 cub. centims.; the total capacity may, therefore, be taken as somewhere about 1260 cub. centims. I do not think this estimate can be far from the truth, and although it cannot pretend to the exactitude of a measurement made on a complete skull, it is probably more trustworthy than those which have been arrived at in the case of the Neandertal calotte.

The remarkable correspondence which we have traced between the Gibraltar and some forms of Australian skull ceases with the cranium. In the face of the Gibraltar skull there is nothing Australian, scarcely, indeed, a feature which recalls in particular any of the existing races of mankind; it is human, but of a singular and unfamiliar aspect. The large round orbits, the broad nasal aperture, bounded by snout-like projecting walls, the upper jaw distinguished by its unusual height and the convex curve taken by its deep alveolar region below the concavity immediately under the nose; these together with the excessive length of the face as a whole, form an assemblage of characters altogether strange and peculiar.

The Orbits.—These, as measured from the margin of the lachrymal canal, are 43 millims. in breadth, that on the right side is 39 millims., and that on the left 40 millims. in height. The orbital index is therefore 91·9. This is surpassed by some megaseme races such as the Chinese, with an index according to BROCA of 93·1, or the Polynesians with an index of 92·5. Among the Australians the orbit is not deficient in breadth, and compares very well in this respect with that of the Gibraltar skull, but there is a falling off in height, so that the index is only 78·9 according to BROCA, or 84 according to Sir WILLIAM TURNER; in our Australian skull, No. 998, the breadth is 43 millims., the height only 35 millims.

A very important character common to all the skulls of the Neandertal group is to be found in the distribution of the height of the orbit: thus if a line be drawn from the nasion to the middle of the fronto-zygomatic suture (by a stretched thread, most conveniently) then the height measured from this chord to the vertex of the orbital margin will be found to be greater than the corresponding height in Australian skulls. In the latter, the height ranges between 8 and 10 millims.; in the Neandertal group measurements give:—

Neandertal (from a cast)	19–20.	Spy II (from a cast)	14–15.
Spy I ,,	14–15.	Gibraltar ,,	12–14.

From this we may infer that the diminution in height of the Australian orbit has been effected chiefly in the region situated above the aforesaid sutures.

A part of the effect may be due to a displacement of one or other of the sutures on which we have based our measurements. In this connection an observation of KRAMBERGER is of interest. He remarks that if a line be drawn from the fronto-zygomatic suture of one side of the skull to that on the other, it will be found that the naso-frontal suture lies above this line in recent races, but below it, or at least coincident with it, in the Krapina fragments. As regards recent races, this statement is, I fear, too general, it is probably true for some, but certainly not for all. KRAMBERGER does not explain by what means the line uniting the fronto-zygomatic sutures is to be drawn; it may of course be accomplished, though not satisfactorily, by stretching a thread, but a safer way would seem to be to measure the height above some definite horizon, by preference the alveolo-condylar plane of BROCA: tested in this way, I found KRAMBERGER'S statement applied well to an average English skull, the nasion having a vertical distance of 70 millims. above the given plane and the fronto-zygomatic suture of 62 millims. only. The case was found to be very different however with Australian skulls; some, it is true, gave confirmatory results, as, for instance, No. 991 with the nasion 67 millims. and the fronto-zygomatic suture 63 millims. above the plane, but in others, such as Nos. 998 and 999, all three sutures stood at the same level, while in others again, No. 995 for instance, the nasion measured 61 millims. and the fronto-zygomatic suture 64 millims. above the plane. The skull of a Zulu followed KRAMBERGER'S law, the nasion having a height of 60 millims. and the zygomatic suture of 55 millims.

Whatever may be the rule for the majority of existing races, KRAMBERGER'S statement cannot be applied to the Australian skull; but were the facts even as this distinguished observer asserts, it does not appear to me that they furnish a sufficient basis for the conclusion he derives from them, viz., that the frontal bone is elongated towards the nose ("dass das Stirnbein nasalwärts verlängert ist"). On the contrary, the nasion, as shown by angular measurements (p. 323), is not rotated forwards and downwards to a markedly greater degree than in the Australian skulls we have described: and if a comparison be made on the basis of the Frankfort line, it will be found that the nasion of the Gibraltar skull stands in some cases above, and in others lies below, that of the Australian skulls. Owing to the absence of fixed points in the skull, it is difficult when two sutures change their relative position to determine the relative share of each in the movement; but in the present case I am inclined to think that the displacement has chiefly affected the fronto-zygomatic suture which has been shifted upwards in recent skulls as a consequence of the shortening of the fronto-zygomatic process.

An additional peculiarity in the orbit of the Gibraltar skull is afforded by the absence of a well defined lower margin, the floor of the orbit passing into the cheek by a continuous convex curvature. In the Australian skull and more markedly in the case of other existing races, a sudden change of slope distinguishes this region, and a slight upward growth of the maxilla and jugal has given rise to a distinct marginal ridge, so that the height of the orbit is a little greater within the margin than immediately over it. The difference is clearly shown in fig. 22, which represents sections parallel to the sagittal plane passing through the orbits and the cheeks.

The Nose.—The nasal aperture measures 34·5 millims. in height and 33 millims. in breadth, the index is therefore 95·65. The largest index hitherto recorded in other races is 72, which is cited by TOPINARD from BROCA'S register as obtained from two Hottentots. Nothing comparable is to be met with among the Australians: the maximum index given for this race by Sir WILLIAM TURNER is 60·5. The wall is entire for two-thirds of its course on the left side of the aperture, but the upper one-third is broken; it is unusually thick, measuring 2 millims. across at the fractured margin, which is about 2 millims. distant from the original edge.

The nasal spine is well marked and projects forwards and upwards so that its broken extremity stands 3 or 4 millims. above the lower margin of the nostrils.

The bridge of the nose immediately below the naso-frontal suture is convex from side to side but concave from above downwards. Lower down at the level of the lower margin of the orbit (fig. 23) its walls, where they are formed by the ascending process of the maxilla, project forward with a slight outward convexity to a greater distance than in the Australian Skull, No. 998, and the jugal continues the general direction backwards with an unusual degree of conformity. Still lower down, at the level of the infra-orbital foramina and the lower margin of the zygoma, both maxilla

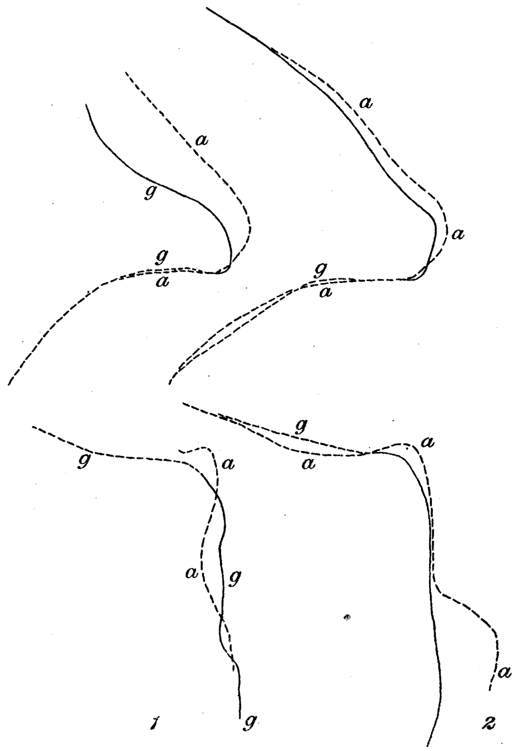

FIG. 22.—The right (1) and left (2) orbits of the Gibraltar skull (*g*, *g*) and South Australian skull, No. 998 (*a*, *a*), compared by superposition of profiles drawn parallel to the sagittal section and passing through the outer side of the second premolar tooth in (1) and between the canine and first premolar in (2). ($\times \frac{2}{3}$.)

and jugal have approximately the same general backward slope, so that the distinction between nose and cheek is confused (fig. 23).

The Face.—The length of the face, measured from the nasion to the broken edge of the upper jaw, is 74 millims., but its true length, as judged from the general level of the alveolar margin, cannot have been far short of 81 millims. The face of the

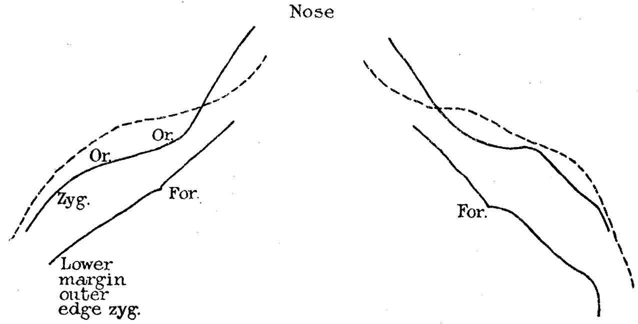

FIG. 23.—Horizontal sections through the face of the Gibraltar skull (continuous lines) in the nasal region, and one such section through the face of the South Australian skull, No. 998 (broken line) for comparison. The superposed sections are taken through the lower margin of the orbit (Or.) and the zygoma (Zyg.). The section below passes through the infra-orbital foramen (For.). ($\times \frac{2}{3}$.)

Australian Skull, No. 998, is only 70 millims. in length and the longest face known among other races of mankind, that of the Eskimos, is 78·4 millims.

The canine fossa, as observed by HUXLEY, is absent or scarcely marked, the ascending process of the maxilla being convex from side to side.

The infra-orbital foramen on each side is broken up into several foramina: two on the right side and three on the left, the lowest in each case being the largest. In connection with this a very peculiar feature may be mentioned; the maxillary jugal suture is accompanied by a second suture which lies nearer the middle line and extends from one of the infra-orbital foramina on to the floor of the orbit. On the right side the two sutures are separated by an interval of 5 millims. and can be traced for a distance of 5 millims. within the orbit. Sir WILLIAM TURNER mentions a similar peculiarity in five crania from the Admiralty Islands, and represents it in a figure of one of them.* I have also observed it in two skulls of gorillas in the Museum of the Royal College of Surgeons.

The under surface of the zygomatic process, where it separates the facial from the infra-temporal surface, seems to pass into the jugal by a gentle curvature, without any downwards growth near the suture, and there is consequently no sub-zygomatic notch in this region such as is generally developed to a greater or less extent in recent races. A closer examination, however, shows that the lower angle of the zygoma is somewhat broken on each side.

The surface of the bones of the face is remarkably smooth and there is a marked absence of muscular asperities, recalling in this respect some negro skulls.

The Upper Jaw.—A small fragment has been broken out of the alveolar margin in front carrying the two median incisors along with it, but as the alveolar juga are preserved between the remaining teeth, the position of the prosthenion can be determined within very narrow limits.

The length of the basi-nasal line is 106 millims., and of the basi-prosthenion line 112 millims., hence the alveolar index is 105·7, or almost the same as that of the Australian skull No. 998; on the other hand the Frankfort angle amounts to 85°, while that of the Australian skull No. 998 is only 71° or 14° less.

The breadth of the face is given in the following measurements: bijugal, 116 to 117 millims.; bimalar, about 115 millims.; maximum bimaxillary, 106 (+); minimum bimaxillary, 67 millims.

Thus in spite of the retreating slope of the cheek-bones, the bijugal breadth is considerable, slightly greater than the mean for Australians (115·3 TOPINARD), but exceeded by the Lapps (120·2 TOPINARD) and the New Caledonians (121·3 TOPINARD).

The indices of breadth obtained by reference to the nasi-alveolar length taken as 100 are as follows: maximum maxillary, 131; bimalar, 131; bijugal, 143; these are all low, owing to the excessive length of the face.

The prosthenion radius makes an angle of 313° with the initial line, or very nearly

* "Challenger Reports," 1880, vol. 10, p. 58, Plate 3.

the same as the mean (312°) of the eight male South Australian skulls, but 7° more than in the example No. 998. The growth of the upper jaw, however, rotates the prosthenion radius in the opposite direction to that taken by the glabella or nasion, and the prosthenion angle should therefore be read clockwise, and not counter-clockwise, from the initial line, *i.e.*, as the supplement of the angle given above. The effect of this change in the method of reading is to make the prosthenion angle of the Gibraltar skull 7° less instead of 7° greater than that of the Australian skull, No. 998.

The length of the prosthenion radius is 140 millims., identical with that of the skull No. 998; the mean for the eight male South Australian skulls is 135 millims. (*vide* p. 319).

The prognathism, as reckoned on the system proposed above (p. 315), is 5° and 6 millims. (fig. 21, *pr. va*) referred to the Frankfort line, and 6° and 9 millims. as referred to the radius of 90°, and is thus very much less than in the skull No. 998; it is also notably less than the mean for the eight Australian skulls, one of which, however, closely approaches it; this is No. 991 with a prognathism of 5° and 6·5 millims. whether measured from the Frankfort line or the radius of 90°; the prosthenion radius in this skull is shorter, however, than in the Gibraltar skull by 9 millims.

The prognathism of the Gibraltar skull, on whatever system we measure it, is certainly very small, much smaller indeed than might have been anticipated. It is true that the Gibraltar skull is the only example of the Neandertal group in which the prognathism has been determined, but when we consider how immensely greater at all times is the number of individuals which approach the average as compared to those which widely depart from it, we may fairly conclude that judged by probabilities the prognathism of the Gibraltar skull is not greatly removed from the mean for the race. On the other hand, that the degree of prognathism is a highly variable quantity, is shown by the South Australian skulls we have already passed in review; the chances are that it was at least not less so in the Neandertal race, and in that case the clustering about the average need not have been very dense.

There would seem to be a danger of confusing primitive and simian characters; in one respect a low degree of prognathism may be regarded as more primitive than a high degree, though it is certainly less simian, for, as we have seen, the prosthenion is carried forwards and upwards in the course of growth, by which means the prognathism is increased; if this movement of rotation be arrested at an early stage, the resulting character, that is a diminished prognathism, may be regarded as relatively primitive. Something more than this, however, is involved in the low prognathism of the Gibraltar skull, for not only is the rotation of the prosthenion arrested at a comparatively early stage, but the growth of the jaw is diverted downwards, or as we may suppose into a new direction. It is this part of the process which may be regarded as specially human. A reduced prognathism might be expected to follow as a natural consequence of the restricted function of the human jaw, for in a lever of the third order, such as the jaw, a definite advantage accompanies the approximation of the points of application of the power and the load. Thus it is far more remarkable that the negroes should possess a high degree of prognathism than that the white man should possess scarcely any.

In view of these facts and considering the wide interval which separates Neandertal man from the apes, it cannot be asserted that the almost orthognathic character of the Gibraltar skull, however unexpected, is at variance with its otherwise primitive character.

The palate (fig. 24) is large, parallel sided (hypsiloid), and the alveolar walls are

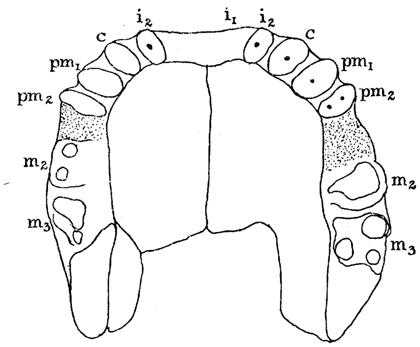

FIG. 24.—Outline of the palate of the Gibraltar skull, drawn with an orthopter. ($\times \frac{2}{3}$.)

continued backwards 10 millims. beyond the third molars. Its length is 63 millims., as measured to the fractured anterior margin, but cannot have been less originally than 67 millims., and its breadth is 70 millims.; it is, therefore, very dolicho-uranic, with an index of 104·5. This is a smaller index than the mean for the Tasmanians (106) or the Australians (107), but in the latter race the index falls in some instances to 101, though in these the absolute length is several millimetres less than in the Gibraltar palate. Thus, notwithstanding the slight amount of prognathism, the palate in its general characters affords an approach to the Anthropoid apes.

The two inner incisors have disappeared along with part of the jaw; the second incisors, canines, first and second premolars are present on both sides, though worn down to mere stumps; the first molar is absent on both sides, that on the left having been lost during life, for its socket is now covered up with consolidated sand; the right second molar is absent, its empty alveolus marks its place, and only the roots of the third right molar are preserved; the second and third molars of the left side are present, but are too fragmentary for measurement. It may be noticed as a singular character that the incisors, canines, and premolars, which are of great length, are brought into a vertical position by a marked downward curvature, something like the fall of the fringe of an epaulette.

Briefly summarising our results, we may remark that the skull of the Neandertal race possesses many features in common with certain flattened skulls which are met with among tribes inhabiting the southern part of Australia; it differs from them in breadth, being markedly broader, in the characters of the glabellar region, and in

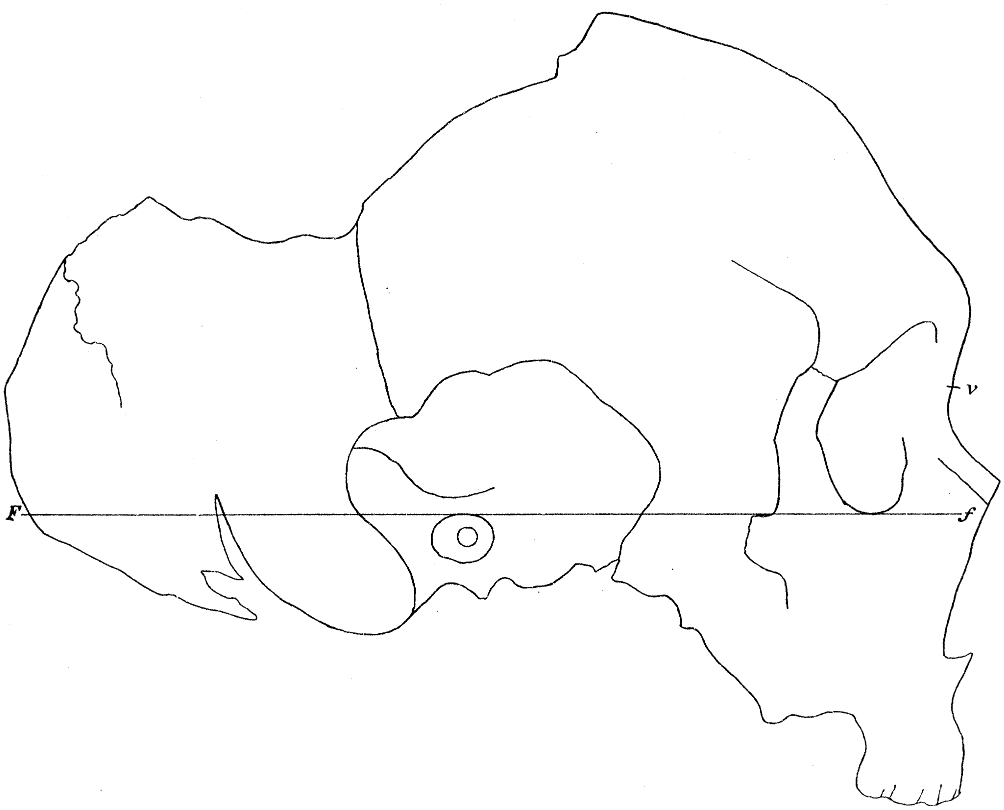

FIG. 25.—Outline of Gibraltar skull as seen from the right side; ν, the nasion; F, f, Frankfort line. ($\times \frac{2}{3}$.)

thickness. The face of the Neandertal race on the other hand is peculiar. The large round, widely open orbits, the projecting broad nose, the retreating cheek bones, the absence of any depression beneath the orbits, the long face, and the low degree of prognathism distinguish it in the clearest manner from the Australian.

The Neandertal race, the most remote from us in time of which we have any anatomical knowledge, and the Australian, the most remote from us in space, probably represent divergent branches of the same original stock. In that most important of all characters, the cranial capacity, the two races are almost identical. In that early stage of the palæolithic period known as the Chelléan, the prevailing race in Europe was characterised by a cranial capacity of about 1250 cub. centims.; by the close of the same period, in the Magdalenian stage, the average capacity of the human race then dominant in Europe had attained the level which now characterises civilised man, *i.e.*, about 1550 cub. centims. This comparatively rapid evolution would seem to imply a correspondingly wide variation, and if this argument is valid important consequences follow from it. For if the variation in modern Europeans be taken as ± 400, then the variation of the

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Neandertal race if as great would be ±300, and this gives us a minimum of 950 cub. centims. and a maximum of 1550 cub. centims., the latter identical with the mean of modern Europeans, the former corresponding with the probable capacity of Pithecanthropus. If the capacity of the Pithecanthropus calotte represents the mean of a race with equally wide variation, then the range would be about ±250 cub. centims., which gives a maximum of 1200 cub. centims., overlapping the Australian minimum and approaching its mean, and a minimum of 700 cub. centims., which takes us very near the maximum capacity of the Anthropoid apes. Looked at from this point of view, the Neandertal and Pithecanthropus skulls stand like the piers of a ruined bridge which once continuously connected the kingdom of man with the rest of the animal world.

APPENDIX.

In seeking for a craniograph which should furnish a true profile or median section of the cranium, I encountered unexpected difficulties. The craniograph of BROCA depends for its accuracy on a "light hand" (TOPINARD) and thus involves a personal equation, which may greatly affect the results. The orthopter, now much used by anthropologists, is open to a similar objection, and to another more serious still, for it does not furnish in all cases a true median section, certainly not in skulls such as we have had under consideration, since lateral prominences such as the supra-orbital region of the frontal torus intervene between the eye and the true profile, which is consequently concealed, so that the resulting outline is not a profile, either in the artist's sense of the term or in its more exact rendering, but something between the two.

In this difficulty it occurred to me that the simplest and at the same time the most accurate plan would be to surround the skull with a number of needles touching it along the median curve, and sufficiently numerous to precisely register its outline. I found afterwards that the same principle had been made use of by KOPERNICKI* in the construction of his "cephalograph," from which my instrument differs only in details, though these are of some importance. Since the outline in this class of instruments is obtained by contact, I propose to call them "haptographs."

The haptograph I have employed in the preceding investigation consists, in the first place, of three similar rectangular mahogany boards measuring 13·5 by 11 by 0·75 inches, with a hole sawn out of the middle to receive the skull. Two of the boards hold the needles between them; for this purpose metal sockets are let into each at intervals corresponding above and below; these are fitted with thumb-screws, which, when tightened up, secure the needles in position. To allow the needles to be readily adjusted to the surface of the skull, the opposed surface of each board is lined with a thin sheet of felt, so that under a gentle pressure of the screws the needles can be pushed in or out, without being inconveniently loose.

* KOPERNICKI, "Description d'un nouveau Crâniographe," 'Bull. Soc. d'Anthropol.,' 1867, II sér., vol. 2, p. 559.

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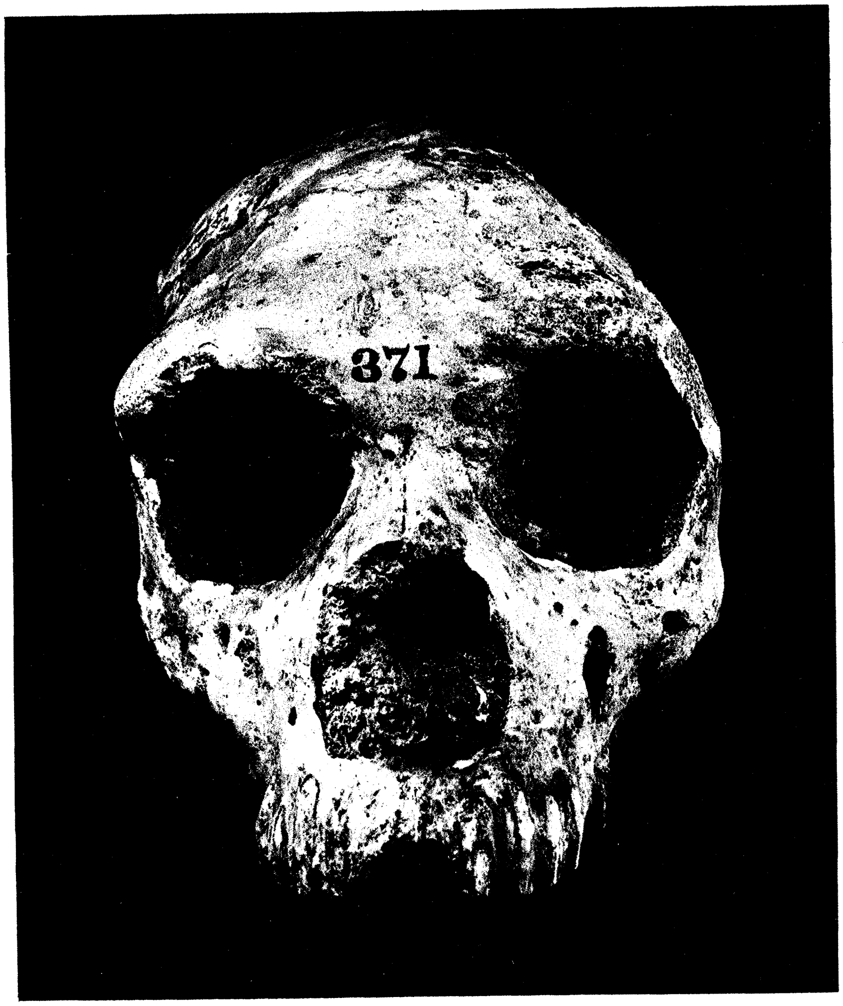
But when the needles have been properly adjusted and secured it becomes necessary to remove the skull, and to accomplish this the two boards forming the frame must have been previously sawn across: for greater convenience and accuracy not through the middle, but as far away from it as is consistent with the object in view. The larger part of the frame is permanently bolted to the third board or base, the smaller is keyed against the larger and fastened to the base by thumb-screws working in metal sockets. When the skull is to be removed, these screws are loosened till they are free of the base; the smaller segment of the frame is then taken away and, after removal of the skull, restored to its place and firmly screwed down. A drawing board which fits the hollow in the middle of the frame is then introduced from below, and brought up into contact with the under surface of the needles, when it is firmly wedged in position. The drawing board bears a sheet of paper cut to shape and fixed on previous to its insertion. The position of the needle points is then recorded with the aid of a small rectangular bar of brass, which is laid flat on the paper, its terminal face being vertical with a vertical groove in the middle. When the vertical groove is brought in contact with the point of a needle it occupies the same position at that point as the surface of the skull did previously: a hole drilled obliquely through the bar so as to pass out through the centre of its lower anterior edge affords a passage to a thin pricker (sewing needle) which marks the paper immediately below the point of the indicating needle. Those needles which are adjusted to the topographical points on the skull are coloured or otherwise marked to distinguish them from the others.

To test the accuracy of the instrument, drawings made by its means should be measured and compared with those obtained with a craniometer, such as FLOWER's. Tried in this way, mine has proved extremely accurate, and diagrams drawn from its records were found to be more trustworthy than those constructed from triangles based on direct measurements of the skull.

Several pieces of accessory apparatus may be used in conjunction with the frame. The legs on which it stands are screwed into sockets, and thus capable of being adjusted in lengths, so that the upper surface of the frame can be rendered horizontal as tested with a spirit-level. The median curve of the skull, when the needles are in close contact around it, is parallel to the upper surface of the frame, so that both are horizontal at the same time. In this case we may proceed to make use of an orthopter. A sheet of prepared glass is carried in a light wooden frame supported by legs which fit into sockets in the upper board of the frame, thus ensuring fixity in its relation to the skull over which it lies. The legs of this frame are also adjustable, so that the glass may be brought into the horizontal position parallel with the median plane of the skull. When this is the case drawings may be made with the orthopter.

It is sometimes necessary to obtain outlines parallel to the profile, but at a distance from it, as, for instance, through the roof of the orbit; this can be easily



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accomplished by screwing on an additional frame of double boards with needles between. Other frames may be constructed to stand vertically on the first, and these are useful for obtaining outlines in other directions than the profile, and especially to determine the position of the Frankfort line.

Compared with other craniographs, this apparatus is far from costly; mine was constructed in my laboratory at an expense of something under £2.

I cannot conclude this paper without expressing my sense of the kindness shown to me by the late Professor C. STEWART, who afforded me every facility for the study of the Gibraltar skull. I am also indebted to Professor G. BOURNE for his readiness in giving me free access to the University collection of skulls, and particularly to Mr. E. S. GOODRICH, who was good enough to read through my manuscript before it was sent to press.

DESCRIPTION OF PLATE 29.

FIG. 1.—The face of the Gibraltar skull, front view, from a photograph. ($\times \frac{7}{12}$.)

FIG. 2.—Lateral view of the right side of the Gibraltar skull, from a photograph. ($\times \frac{7}{12}$.)

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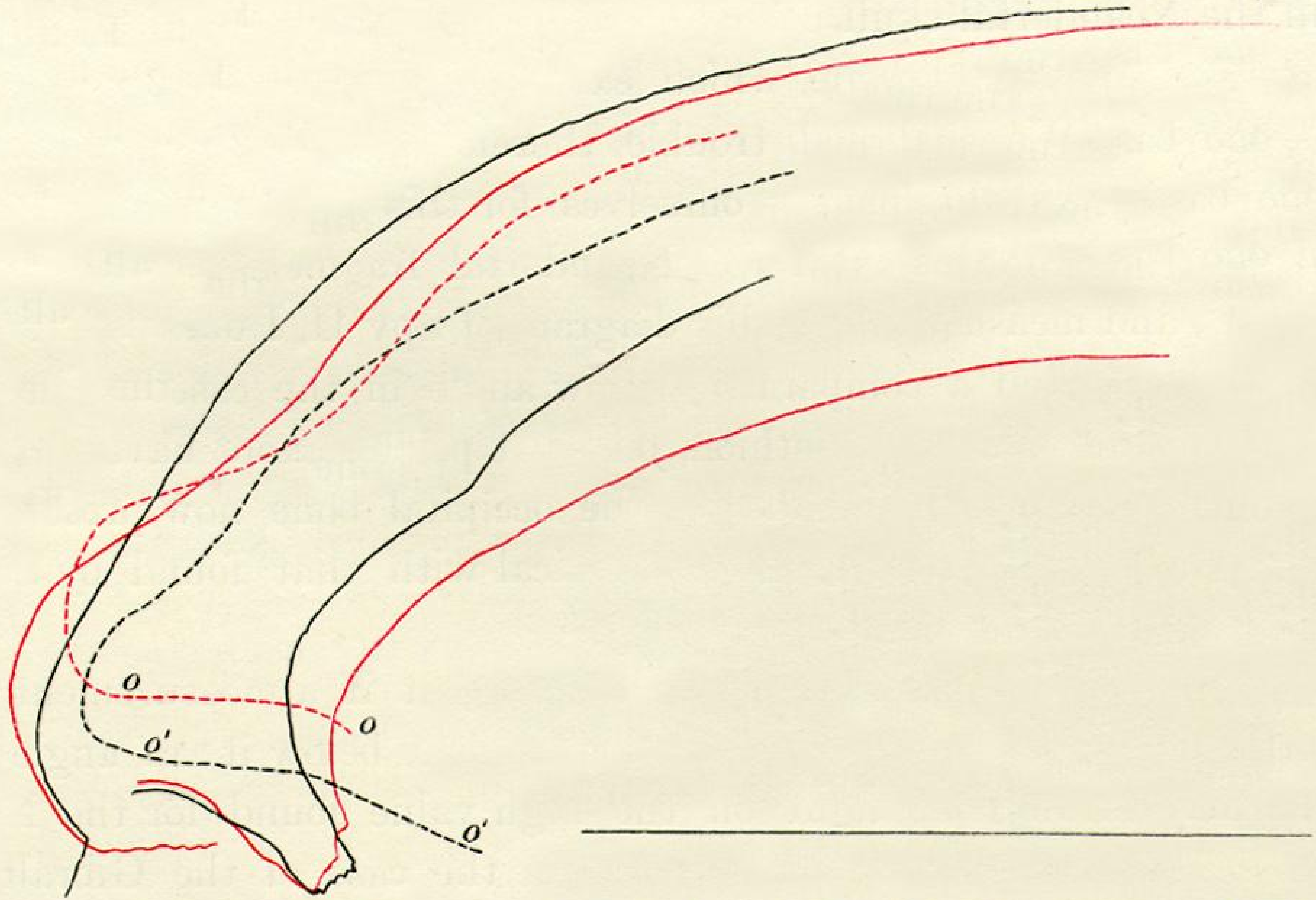


IG. 4.—The attitude of the frontal bone in the Gibraltar skull (red outlines) and in the South Australian skull (No. 998) (black outlines); *o*, *o*, curve through the median third of the roof of the orbit in the Gibraltar skull; *o′*, *o′*, in the South Australian skull (No. 998). (Natural size.)

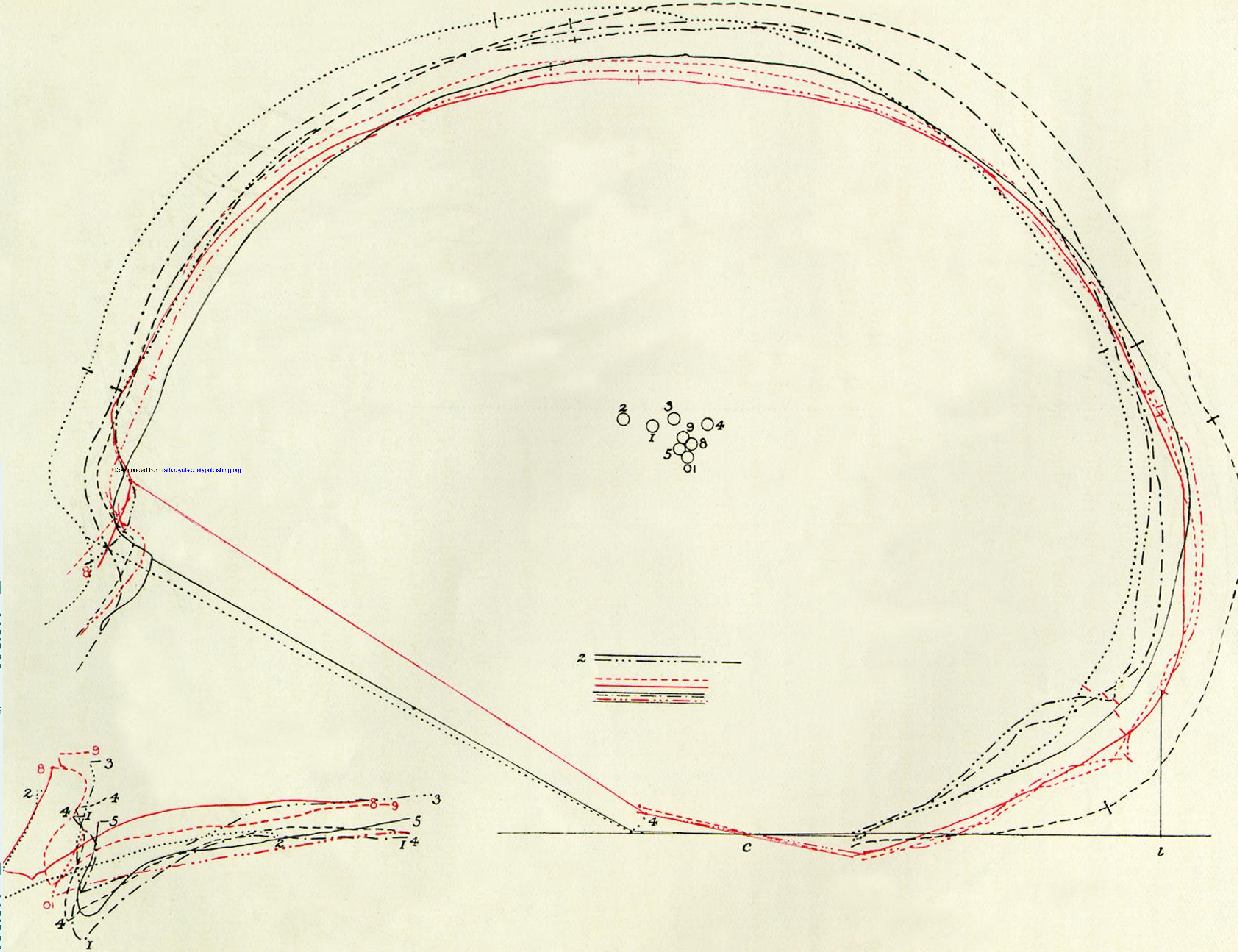


FIG. 6.—Profiles of eight skulls of South Australian males, superposed on the centre of the occipital foramen in parallelism with the Frankfort line. The skulls are numbered 1, 2, 3, 4, 5, 8, 9, and 01. The numbered circles in the middle correspond to the respective centres of figure. (Natural size.)

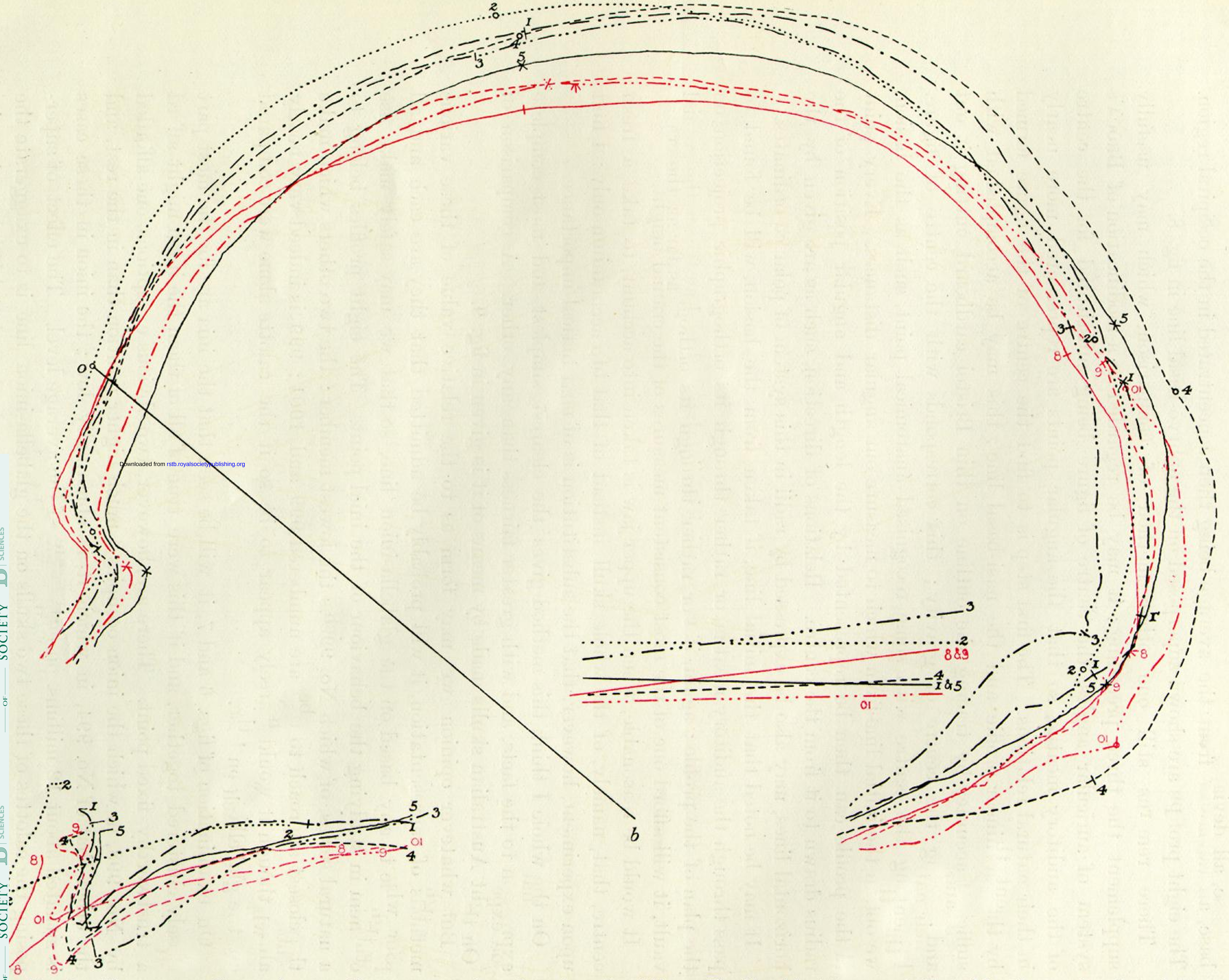
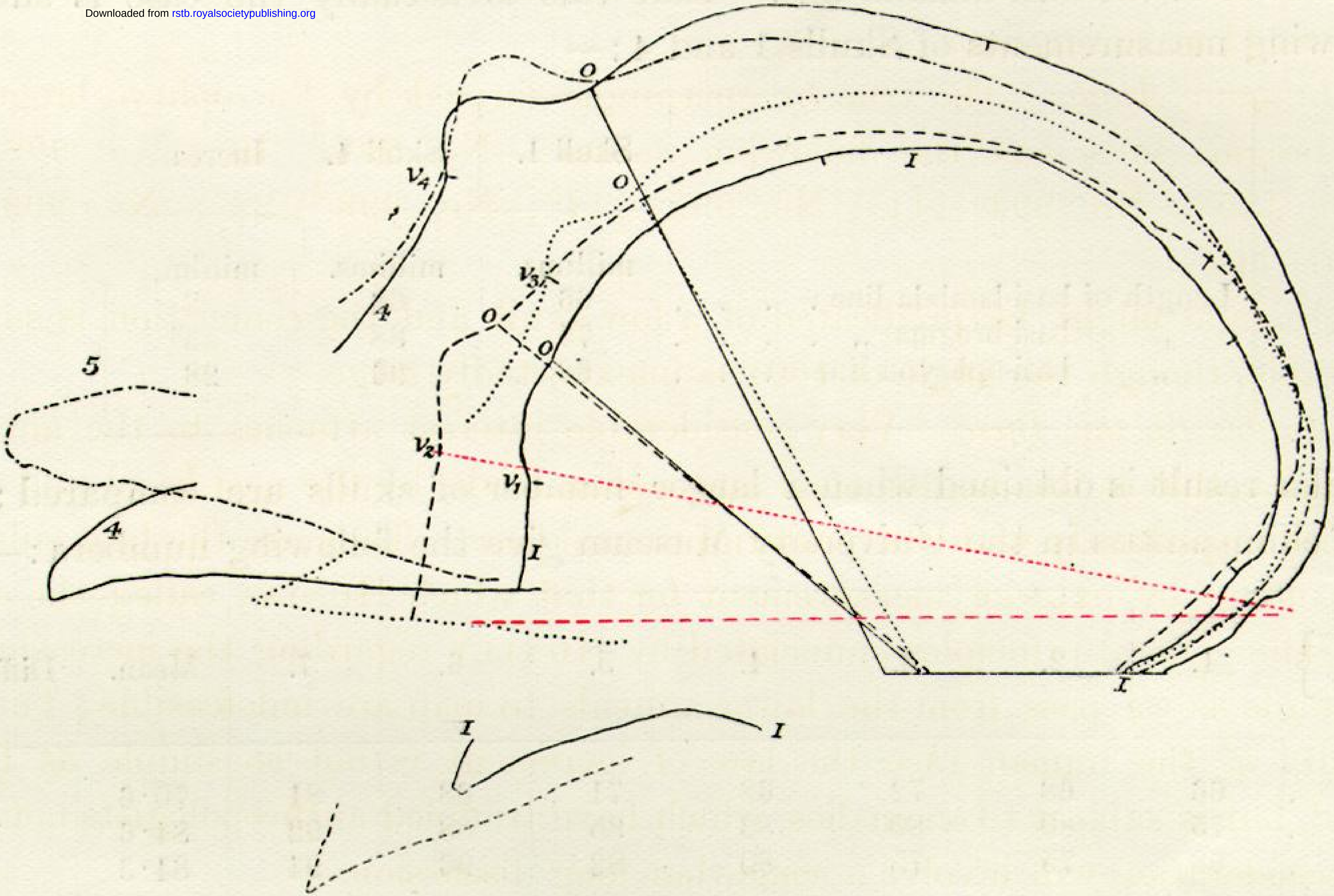


FIG. 8.—The same profiles as the preceding, superposed on the ophryo-basal line. The Frankfort lines are indicated by the numbered straight lines. (Natural size.)



IG. 10.—Median profiles of five skulls of Chimpanzees in various stages of growth, superposed on the foraminal axis. The red lines are the Frankfort lines, the upper one of profile No. 3, the lower of profile No. 2. ($\times \frac{2}{3}$.)

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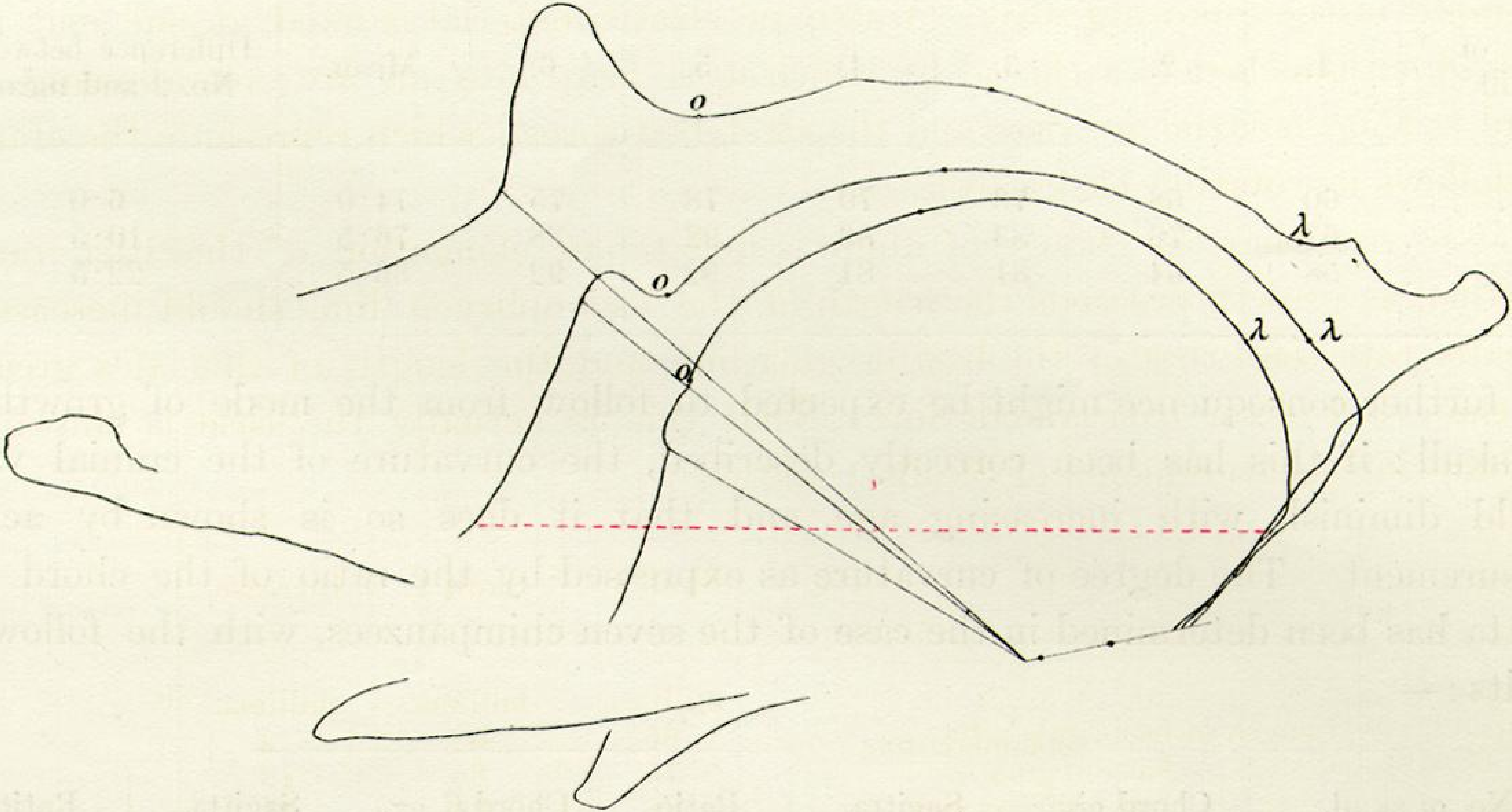
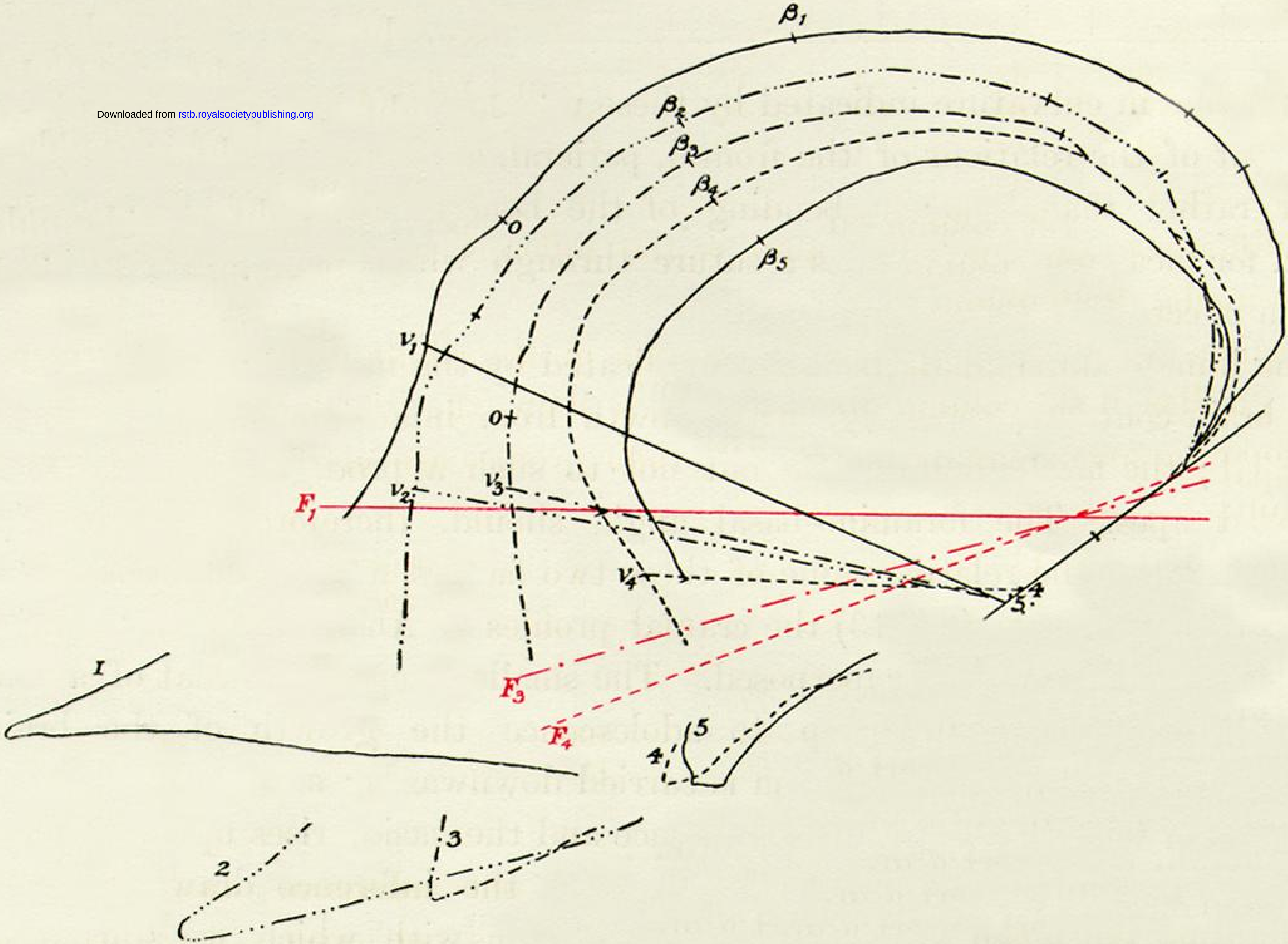
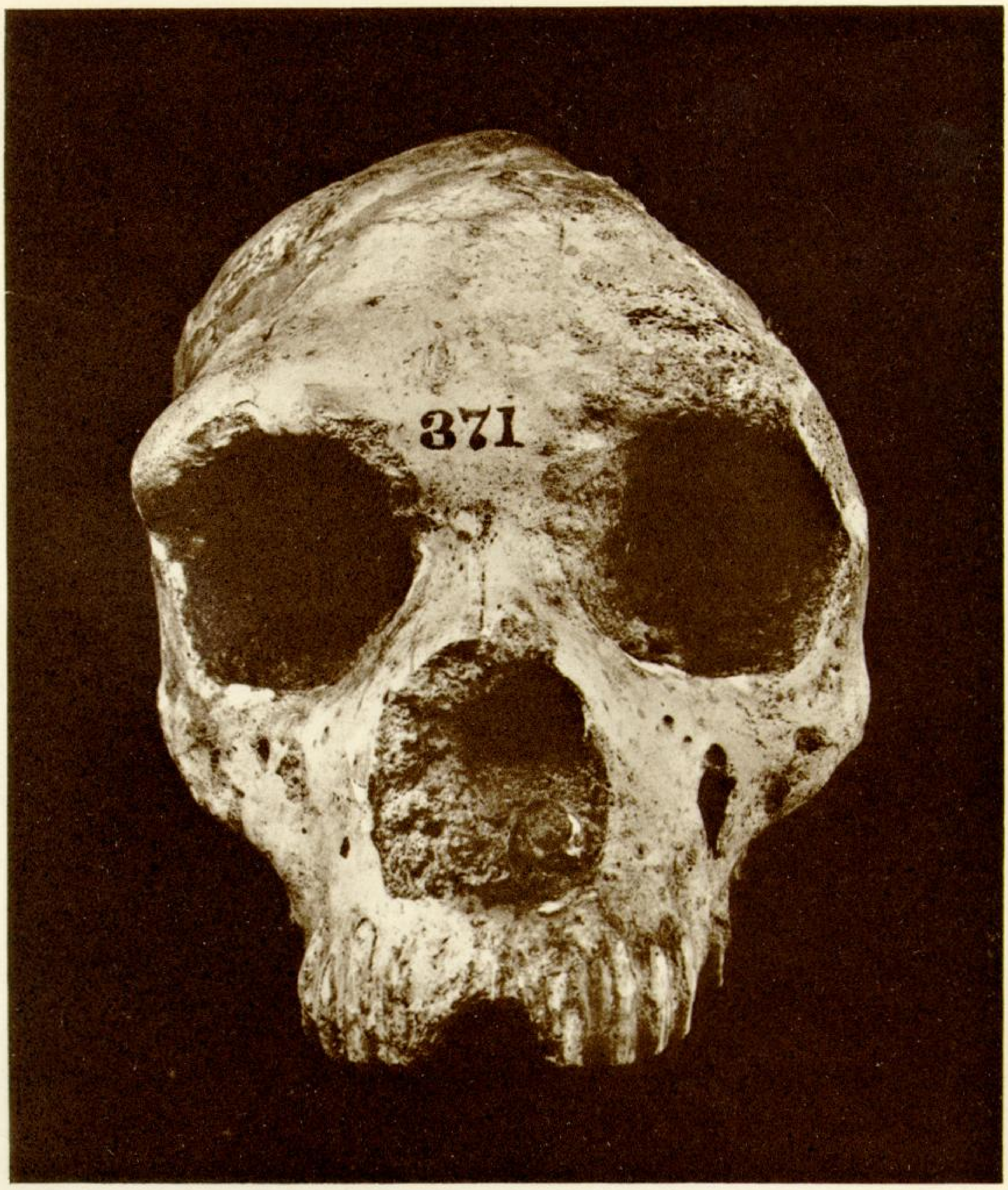


'IG. 11.—Median profiles of three skulls of Gorilla in different stages of growth, superposed on the foraminal axis. The red line is the Frankfort base of the middle profile. (× ½.)



IG. 12.—Median profiles of five skulls of Orang in different stages of growth, superposed on the foraminal axis. The red lines are the Frankfort lines of the first, third, and fourth profiles. ($\times \frac{2}{3}$.)



THE GIBRALTAR SKULL.

Fig. 1.—The face of the Gibraltar skull, front view, from a photograph. $(\times \frac{7}{12}.)$

Fig. 2.—Lateral view of the right side of the Gibraltar skull, from a photograph. $(\times \frac{7}{12}.)$