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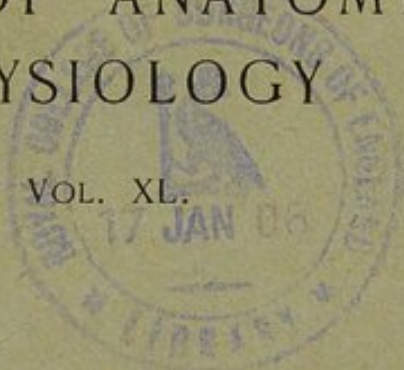


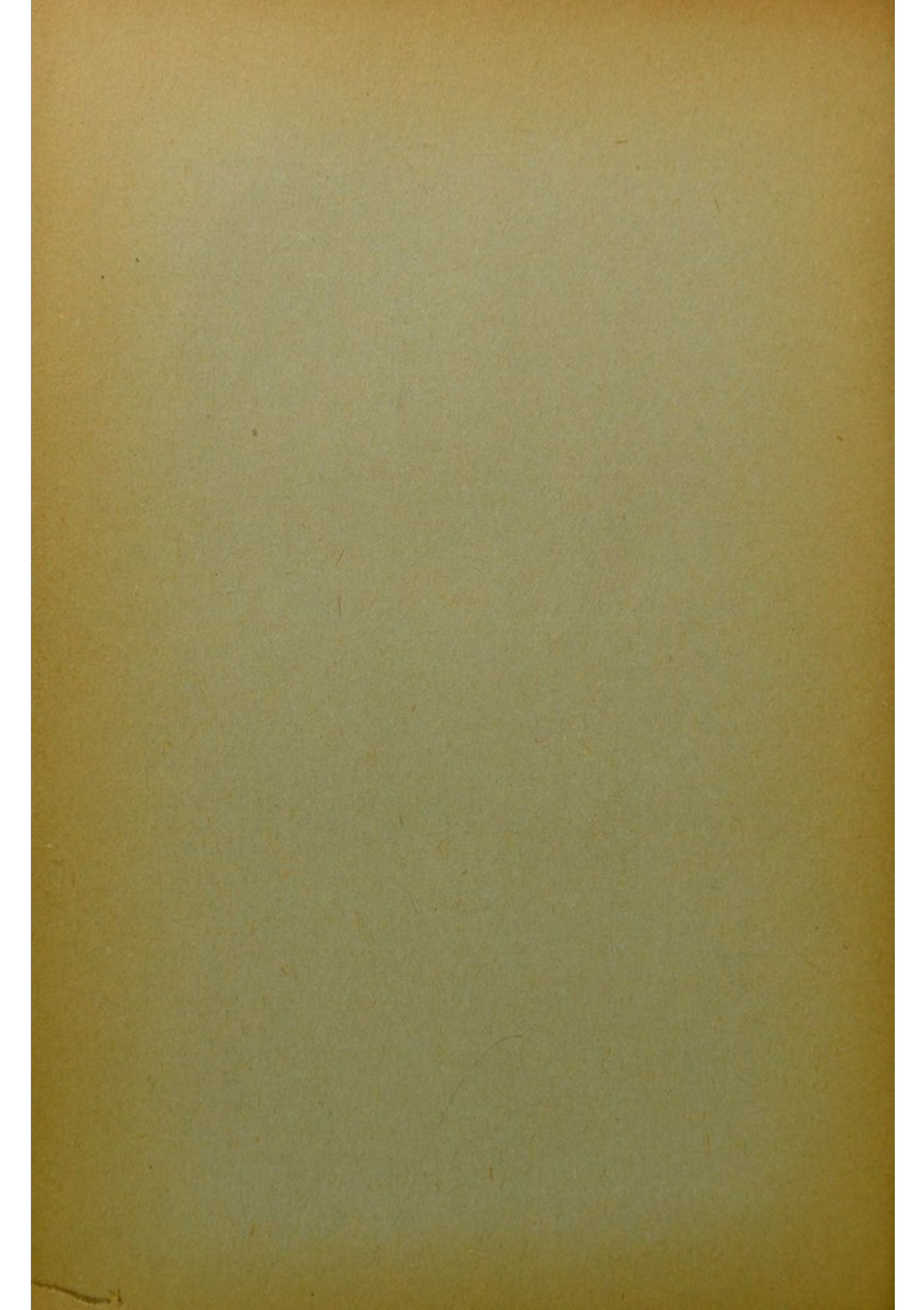


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## A NEW METHOD OF DEMONSTRATING THE TOPOGRAPHICAL ANATOMY OF THE ADULT HUMAN SKULL.

By SYDNEY R. SCOTT, M.S., M.B. Lond., F.R.C.S. Eng., L.R.C.P. Lond.

IN this paper I do not propose to discuss the subject of cranial topography from an anthropological point of view: I propose rather to describe a system by which it is possible to demonstrate the cranium by means of diagrams and drawings. To those naturally skilled in draughtsmanship, perhaps such a system as that which I bring forward appears unnecessary. But I know of no method which has been prepared for the purpose of introducing to the uninitiated the manner in which the average skull can be correctly reproduced by diagrams and drawings, from below, from above, from the front, and from the side. To do this an accurate knowledge of the topography of the different cranial foramina and processes is necessary, and, by a series of some four hundred measurements, I have striven to find the least variable landmarks of the skull, upon which to base this system.

One finds that whereas the variations in contour and dimensions of the vault of the adult skull are considerable, the variations in the distances between certain foramina and other readily identified landmarks of the base and facial portions of the skull, are comparatively small.

The degree of prominence of the malar bones, and the curvature of the zygomatic arch, are subject to variation. The variations in shape and size of the alveolar arch depend upon the presence or absence of sound teeth; thus it is in the vault, zygoma, and alveolar arch that the widest degrees of variability are found.

Certain well-known data have been confirmed, and additional data have been obtained from the records of the series of four hundred measurements which have been specially taken in twenty different skulls.

These observations reveal the remarkable approximate constancy in relation of the chief foramina and processes of the anterior half of the base of the skull, and of the lateral aspect of the cranium and also of the lower half of the facial aspect.

The relations of these foramina to each other can be represented by geometrical figures, which are accordingly constructed and serve as a groundwork, upon which the chief foramina can be indicated; and the variable elements, *e.g.* the contour of the vault, are added last of all.



## I. THE NORMA BASILARIS.

To illustrate the norma basilaris, two triangular figures are constructed as follows (see fig. 1):—<sup>1</sup>

C N S and C N S" are two right-angled isosceles triangles, the side C N being common to both triangles and equal to C S and C S".

Then the points N, S, and S" correspond to the relative positions of the post-nasal spine and the two stylo-mastoid foramina respectively, while C corresponds to a point which would be just behind the basion. C is the central point of the base of the skull, and on an average is within the foramen magnum and half a centimetre from the anterior margin of that foramen. For practical purposes we may remember that the basion is just in front of the central point.

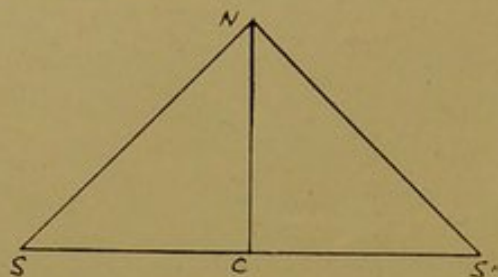


FIG. 1.—N, the post-nasal spine; S, S", the stylo-mastoid foramina; C, the "central point" (in the average adult skull half a centimetre behind the basion).

The line C N is then prolonged to A, making N A equal to C N: A is joined to S and S" respectively, thus another isosceles triangle, S A S", is produced (fig. 2).

The point A corresponds to the position of the anterior margin of the anterior palatine fossa.

The sides A S and A S" represent the well-known guide-lines to the following foramina etc.:—The anterior palatine fossa, the posterior palatine foramen, the pterygoid fossa, the foramen ovale, the foramen spinosum, the vaginal process of the tympanic plate, the stylo-mastoid foramen.

The posterior palatine foramen is situated on the line A S (we may call this the palato-styloid line), two-fifths the distance from the point A. (For the uniformity of this position, see charts 10 and 11.)

Midway between the posterior palatine foramen and the stylo-mastoid

<sup>1</sup> The illustrations accompanying this paper have been produced by following the description given in the text, and without reference to any skull or any other illustration. As mentioned in the text, it has been my purpose to devise a method whereby anyone unskilled in perspective drawing can delineate the essential topographical features of the skull merely by applying accurate anatomical knowledge.



foramen of the same side, is the narrow partition of the sphenoid, which separates the foramen ovale and the foramen spinosum—the latter being on the palato-styloid line, the former being generally a little to the inner side of that line, though it also is sometimes on the palato-styloid line. It will be noticed that the anterior two-fifths of the palato-styloid line corresponds to the hard palate, the posterior two-fifths to the part of the base between the stylo-mastoid foramen and the foramen spinosum, while the middle fifth of the line runs across the pterygoid fossa.

As regards the hard palate, its length is a quarter that of the whole length of the base and its posterior lateral angle is just behind the posterior palatine foramen, while the outline of the hard palate resembles that of a Norman arch.

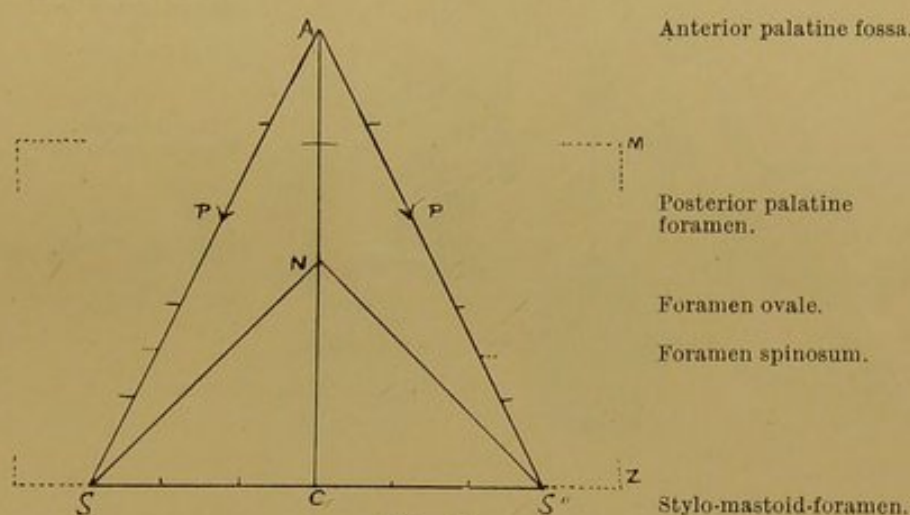


FIG. 2.

With respect to the foramen magnum, we have seen that its anterior margin lies half a centimetre in front of the "central point." The foramen is nearly circular, and its diameter is equal to a sixth of the total length of the base of the skull (see charts 6 and 7).

The external occipital protuberance varies in position more than do the other landmarks above mentioned; the protuberance is as a rule, however, about half-way between the posterior margin of the foramen magnum and the posterior outline of the vault of the skull. The exact position varies with the shape of the vault.

The median transverse line on each side either bisects the middle, or the anterior and middle thirds, of the occipital condyle, and skirts the posterior margin of the jugular foramen; it next crosses the stylo-mastoid foramen, and, if prolonged, runs along the tympanico-mastoid fissure to the posterior margin of the external auditory meatus (figs. 3 and 4).

If the stylo-mastoid foramen of one side is joined to the opposite



posterior palatine foramen, the line corresponds to the direction of the carotid canal. The two "carotid lines" intersect each other on the posterior margin of the vomerine plate (fig. 3). The entrance to the canal lies immediately in front of the middle of the jugular fossa, and the foramen lacerum medium lies on the "carotid line," nearer the middle line than, and internal to, the foramen ovale (fig. 3).

The root of the internal pterygoid plate runs into the anterior margin of

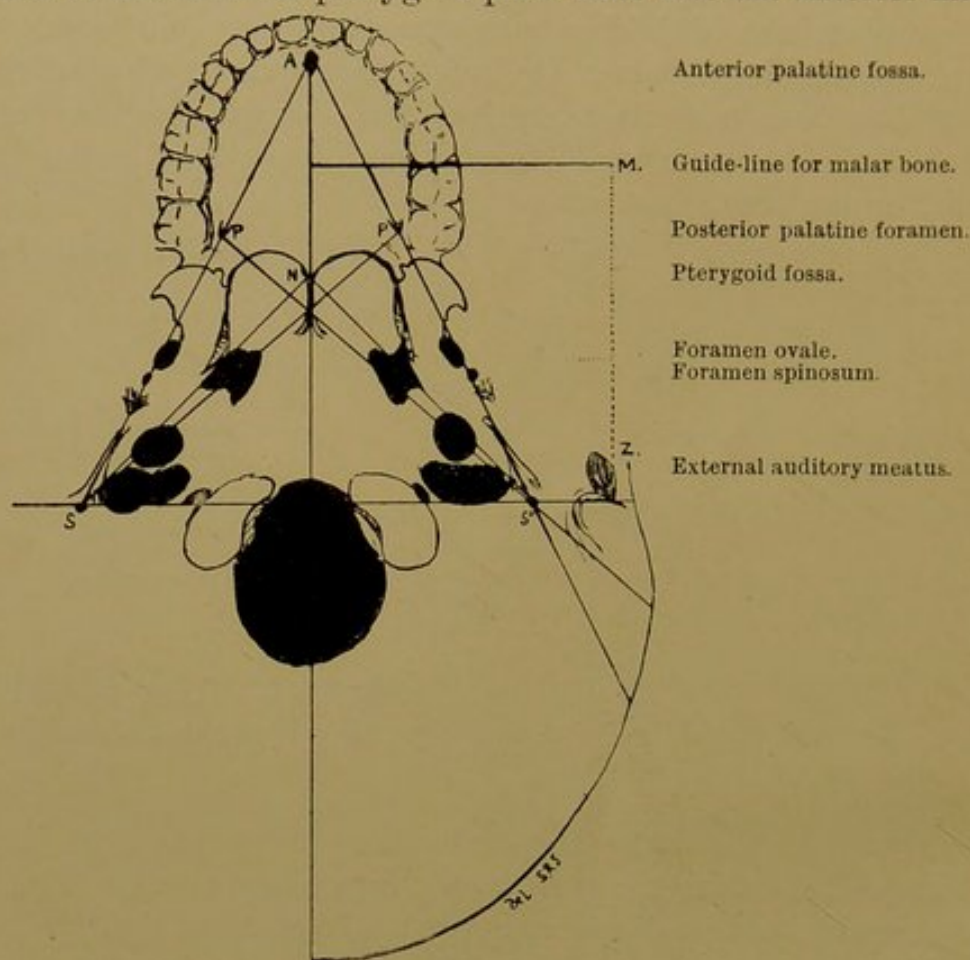


FIG. 3.—A S' = "palato-styloid line," prolonged backwards; P S' = "carotid line"; S S' = mid-transverse line; M Z = malar-zygomatic guide-line, merely giving an approximate guide for zygoma.

the foramen lacerum medium, and the root of the external pterygoid plate runs into the anterior margin of the foramen ovale (figs. 3 and 4).

If the "carotid line" be prolonged backwards it crosses the apex of the mastoid process, and if the palato-styloid line be prolonged backwards it runs along the digastric fossa (figs. 3 and 4).

The superior and inferior curved lines of the occipital bone curve outwards and forwards from the external occipital protuberance, and from the external occipital crest towards the mastoid process and the styloid process respectively (fig. 4).

Turning to the zygomatic arch, the anterior limb and the three posterior roots are constant; but the curvature of the arch and the extent of protrusion of the malar bone forwards and outwards varies, as is well known, in different skulls (figs. 3 and 4).

The zygomatic processes of the temporal bones run forwards, approximately parallel with each other (fig. 3, Z M, and fig. 4). The malar process of the superior maxilla juts directly outwards from the middle of the

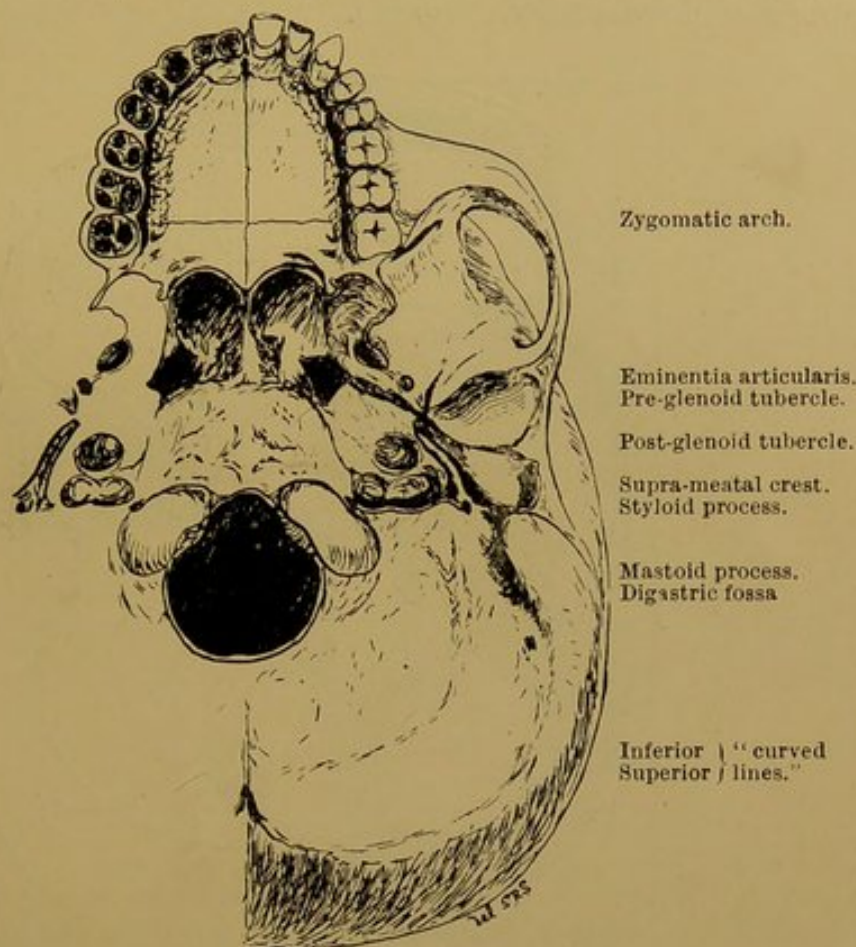


FIG. 4.

outer surface of the latter bone (fig. 3, M, and fig. 4). The eminentia articularis is level with the foramen ovale (figs. 3 and 4). The post-glenoid tubercle is level with the entrance to the carotid canal and in front of the external auditory meatus. The supra-meatal crest can be seen passing back above the external auditory meatus (fig. 4).

## 2. THE SKULL IN HORIZONTAL SECTION. CRANIAL FOSSÆ.

We may now consider the internal aspect of the base of the skull; the vault having been removed, fig. 5 shows how we may apply a knowledge



of the topography of the norma basilaris to demonstrate the cranial fossæ, by first representing the positions of those foramina which are visible from above as well as from below (see left-hand side, fig. 5). The original scaffolding of triangles has been removed, so that attention should be first directed to the following foramina and other landmarks which are represented on the right-hand side as viewed from below, and on the left-hand side as viewed from above:—Foramen ovale, foramen spinosum, foramen lacerum medium, foramen magnum.

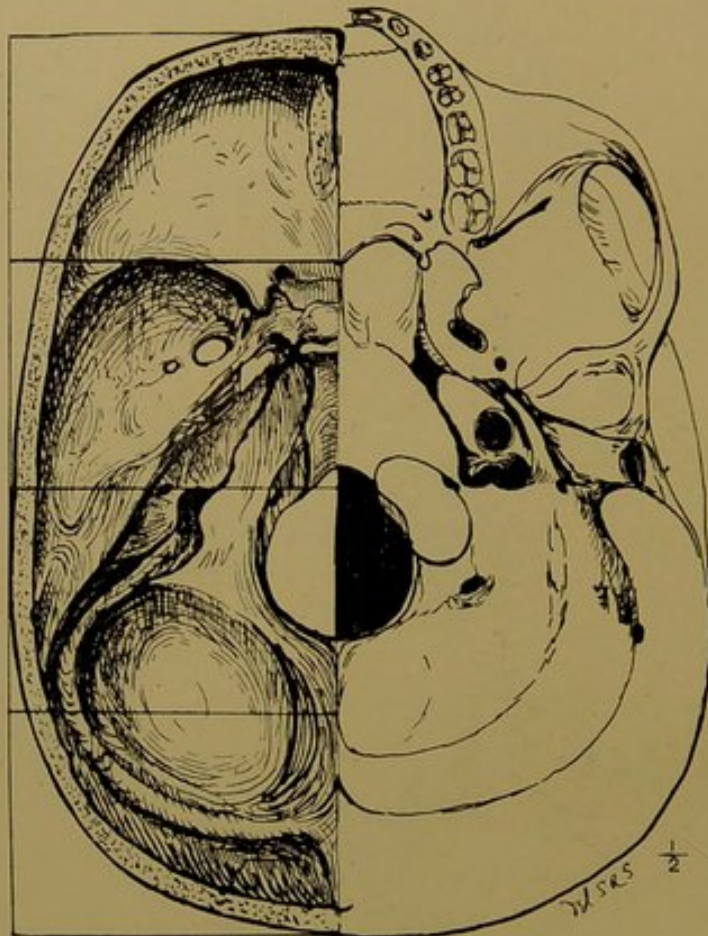


FIG. 5.

The internal occipital protuberance corresponds approximately to the external protuberance, but is at a little higher level. The lower margin of the sulcus of the lateral sinus corresponds approximately to the superior occipital curved line.

The outline of the skull in horizontal section is approximately ovoid, and the transverse diameter is two-thirds the antero-posterior diameter (see charts 1, 14, 15, and 16).

Fig. 5 shows the transverse lines constructed to divide the antero-posterior diameter into four equal parts. Of these the anterior coronal line,

as we may call it, gives the anterior boundary of the temporo-sphenoidal fossa, and the posterior coronal line gives the extreme posterior limit of the temporo-sphenoidal fossa where the superior margin of the petrous portion of the temporal bone joins the vault.

The mid-coronal line lies half a centimetre behind the basion, and crosses the anterior condyloid canal, the jugular foramen, the internal auditory meatus, and then passes across the posterior margin of the entrance to the external auditory meatus. Thus the mid-coronal line crosses the points of

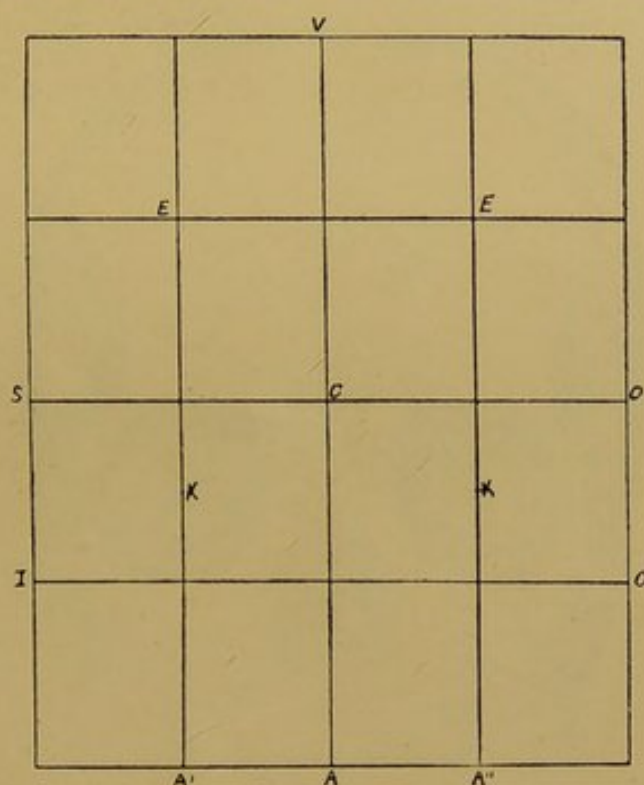


FIG. 6.

exit of the 7th, 8th, 9th, 10th, 11th, and 12th cranial nerves from the cranial cavity (see figs. 4 and 5).

### 3. NORMA FRONTALIS.

To represent the skull from the front, we draw a rectangular parallelogram, of which the adjacent sides are as 6 to 7 (fig. 6; charts 14, 15, 16, 17).

Through the centre of this parallelogram a horizontal line is drawn. This is the mid-horizontal or supra-orbital line *SO* (fig. 6; chart 18). Half-way between this and the base we draw another horizontal line; this is the inferior quarter or infra-orbital line *IO* (fig. 6; chart 19).

Next, we divide the base-line into four equal parts; and then erect median vertical and parallel vertical lines from these points of division, *A*



and A" respectively (sagittal lines). The middle two-fourths of the base represents the alveolar arch as seen from in front, and each parallel or lateral sagittal line intersects the centre of the corresponding orbit (fig. 6, K).

The margin of the orbit can then be delineated. Sometimes the inner and inferior quadrant of the orbital margin approximately corresponds to the axis of the diagonal of the parallelogram (fig. 6). The transverse diameter of the orbit is equal to the vertical diameter (figs. 6 and 7; charts 18, 19, 20).

The fronto-malar and the fronto-nasal sutures are level with the hori-



FIG. 7.<sup>1</sup>

zontal plane dividing the upper from the middle third of the orbit (fig. 7). The inferior border of the nasal bone is level with the horizontal plane dividing the middle and lower thirds of the orbit (fig. 7).

The positions of the optic foramen, the sphenoidal fissure, the sphenomaxillary fissure, can then be indicated (see fig. 7). The maximum diameter of the anterior nares is equal to the minimum diameter between the inner margins of the orbits. The nasal septum, middle and inferior turbinates, are visible through the anterior nares.

The infra-orbital line corresponds to the level of the upper border of the zygoma (figs. 7 and 9).

<sup>1</sup> The diagrams illustrating the stages by which fig. 7 is derived from fig. 6 are not given: the description in the text should, however, make these stages clear.

The sides of the upper half of the parallelogram (fig. 6) form tangents of the outline of the vault, which can therefore be drawn in (fig. 7). The shape of the vault varies considerably, as before mentioned, and no attempt is made to depict other than what we may perhaps be allowed to regard as a fairly typical vault.

#### 4. NORMA LATERALIS.

In several respects this is the most interesting aspect of the skull.

We can deduce the norma lateralis by combining the methods adopted

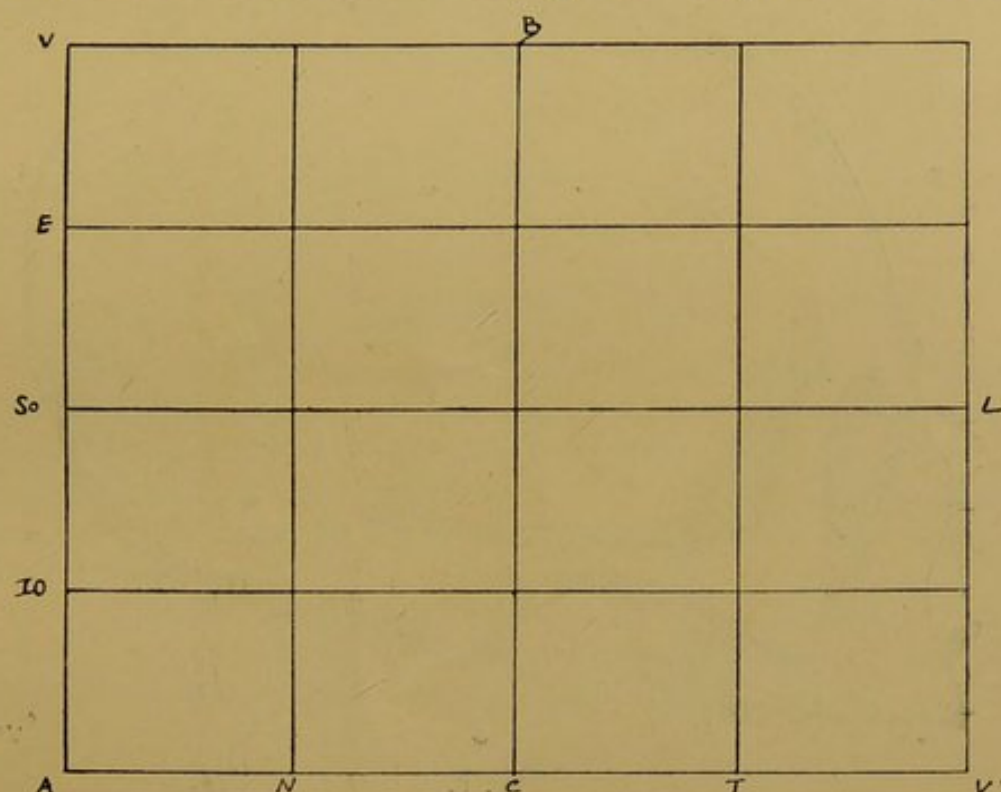


FIG. 8.

in representing the norma basilaris and the norma frontalis. The principle being the same, we take a rectangular parallelogram, the vertical diameter being three-fourths of the antero-posterior diameter (charts 1 and 17). Fig. 8 shows these lines, AV and AV". Each line is now divided into four equal parts—E, SO, IO, N, C, and T.

Through SO and IO horizontals are drawn, and they correspond to anterior and middle coronal lines of the norma basilaris (fig. 5).

The infra-orbital line corresponds to the upper margin of the zygomatic process of the temporal bone. On the mid-coronal line are the posterior margin of the external auditory meatus and the anterior surface of the mastoid process (fig. 9).



The lower margin of the alveolar arch (fig. 9—A N), as viewed from the side, is placed on the anterior quarter of the base-line AV''; the pterygo-maxillary fissure lies on the anterior coronal line.

The anterior limb of the zygomatic arch juts out from the middle of the superior maxilla, about half-way between the infra-orbital line and the alveolar margin (*cf.* figs. 3 and 4).

Tracing along the inferior border of the zygoma from the external auditory meatus, we can indicate the post-glenoid and the pre-glenoid

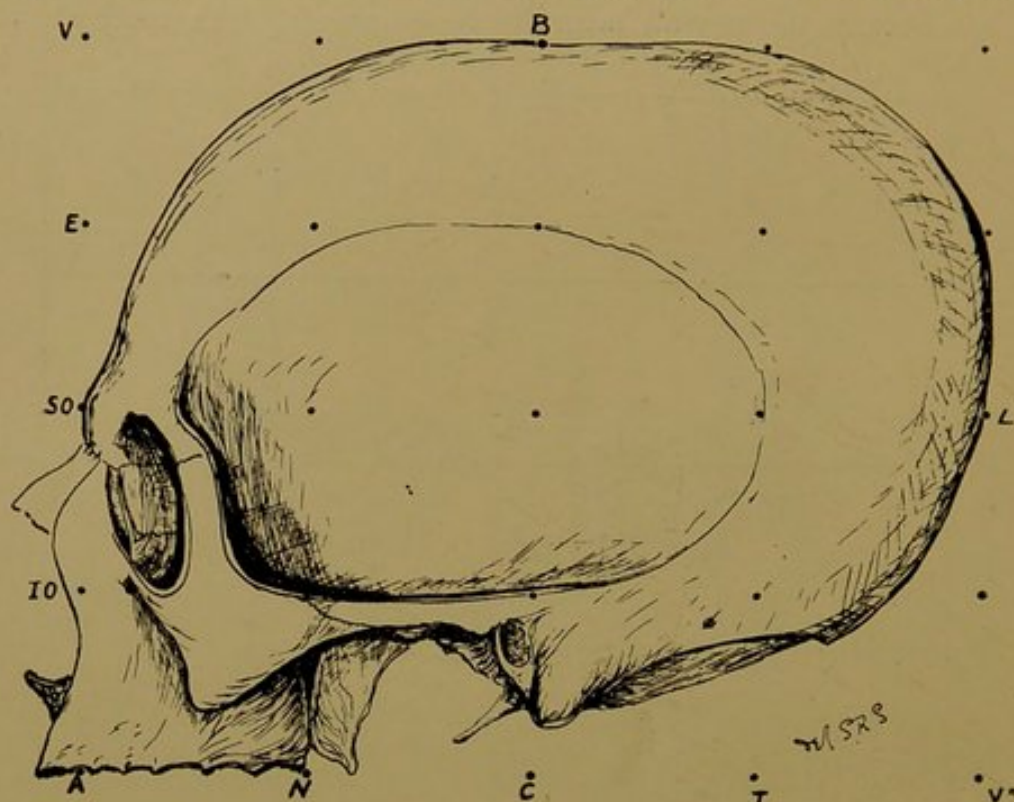


FIG. 9.

tubercles, the latter being midway between the mid-coronal and the anterior coronal lines and corresponds to the eminentia articularis (fig. 9).

The margin of the orbit, as seen from the side, is next represented, and also the fronto-malar and the fronto-nasal sutures, which are level with the junction of the upper and middle thirds of the orbit; the inferior border of the nasal bones lies level with the junction of the middle and the lower thirds of the orbit (figs. 7 and 9). We may rely upon the pre-glenoid tubercle of the eminentia articularis as a safe guide to the structures in the middle fossa of the skull, especially to those in relation to the Gasserian ganglion.

The infra-orbital-zygomatic line prolonged backwards serves as a guide to the highest part of the lateral sinus. Sometimes the postero-inferior



angle of the parietal bone comes well below this line, sometimes it only touches that line. In the latter case the parietal bone forms only a very small part of the sulcus of the lateral sinus.

As regards the base of the skull, the cranial fossæ, and the lateral aspects of the skull, it will be at once evident that the same method of subdivision has been made use of throughout; so we can consider the skull as a whole divided coronally into four sections, by the anterior, middle, and posterior coronal planes, and divided horizontally by the superior, middle, and inferior horizontal planes, the three latter being represented respectively by the frontal, supra-orbital, and infra-orbital planes. (The system might have been further elaborated by use of three sagittal planes—namely, right and left, orbital, and median sagittal planes—corresponding to the vertical lines of the *norma frontalis*.) The uniformity of this system, applied to the skull as a whole, has the advantage of bringing the third dimension into prominence.

#### APPENDIX.<sup>1</sup>

The skulls described include European, African, Asiatic, American, and Australasian races.

Considerable differences in contour exist in the adult skull. The differences are chiefly in the vault of the skull, in the alveolar arch, and in the zygomatic arch. It is otherwise respecting the base of the skull and facial regions, where the actual variations are much less.

The most constant topographical relations are found below the supra-orbital line on the facial aspect, in front of the mid-coronal line on the lateral aspect, and in front of the mid-transverse line on the basal aspect.

#### *Skulls examined.*

Race.	Catalogue No. St Bartholomew's Hospital Museum.		
1. New Hollander	.	.	206
2. European	.	.	207
3. „	.	.	Anatomy Department, Medical School.
4. „	.	.	„ „ „
5. „	.	.	„ „ „
6. „	.	.	„ „ „
7. „	.	.	Private collection.
8. „	.	.	„
9. New Zealander	.	.	203 Catalogue S. B. H. Mus.
10. New South Wales	.	.	202
11. „ „	.	.	201

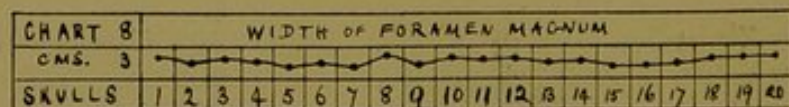
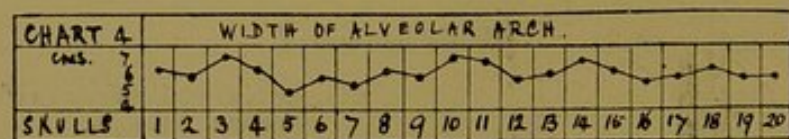
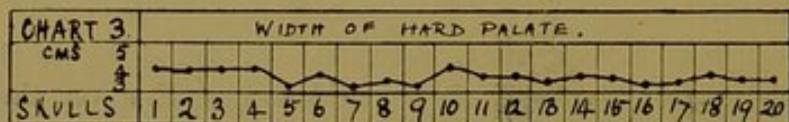
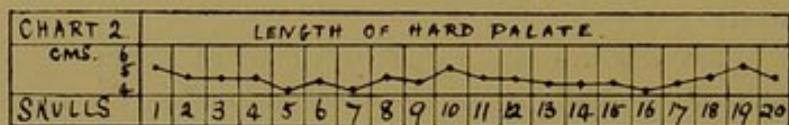
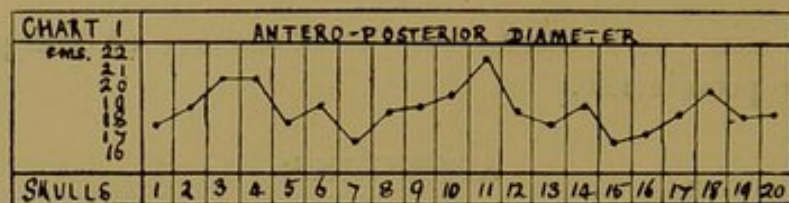
<sup>1</sup> I am indebted to the authorities of St Bartholomew's Hospital Museum for permission to refer to the skulls in question for this paper.



*Skulls examined—continued.*

Race.	Catalogue No. St Bartholomew's Hospital Museum.
12. African . . . . .	196
13. „ . . . .	194
14. Norman . . . . .	209
15. Chinese . . . . .	171
16. Hindoo . . . . .	179
17. European . . . . .	159
18. German . . . . .	167
19. Ancient Briton . . . . .	166
20. Native Maltese . . . . .	165

Chart 1. This diameter is taken from the anterior part of the anterior palatine



fossa to the vertical tangent of the posterior outline of the vault. In nearly 75 per cent. this measures between 18 cms. and 19 cms. We have taken 18 cms. as



representing a typical case. By comparison with charts 14 and 15 we see the relation of total length, height, and breadth of the skull is as  $1 : \frac{3}{4} : \frac{2}{3}$ .

Chart 2. This measurement is taken from the anterior part of the anterior palatine fossa to the post-nasal spine. In over 75 per cent. this is between 4 and 5 cms. We may regard the typical measurement as 4.5 cms.

Chart 3. This is the maximum width of the hard palate, and measures between 3.5 cms. and 4.5 cms. 4 cms. will represent the typical case.

Chart 4. The maximum external diameter of the alveolar arch varies with the presence or absence of well-formed teeth. In nearly 75 per cent. this diameter is between 5.5 cms. and 6.5 cms. The average is taken as 6 cms.

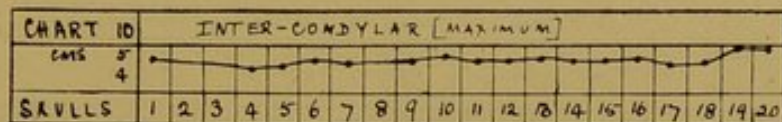
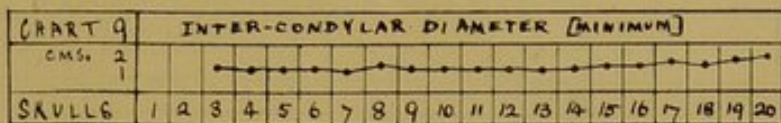
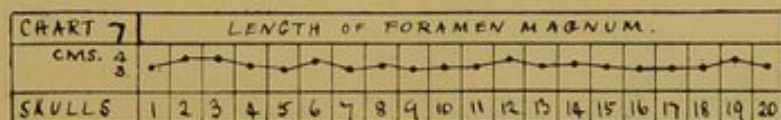
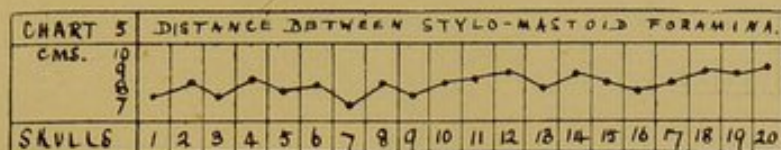


Chart 6. The average distance between the anterior palatine fossa and the basion is 9.2 cms. The average of the majority (in contra-distinction to the average of the total) works out at rather less than 9 cms. For convenience, with a negligible error we take 8.5 cms.

Chart 5. This measurement is between the inner margins of the stylo-mastoid foramina. In over 75 per cent. the distance measures between 8 cms. and 9.5 cms. For the purpose of constructing simple workable geometrical figures, we have taken 9 cms. as representing the typical case. The error is less than two and a half millimetres on each side.

Chart 9. This measurement is taken between the anterior and inner margins of the occipital condyles. Average, 1.5 cms.

Chart 10. This measurement is taken between the outer margin of the occipital condyles, and is very constant, namely, 5 cms.



Chart 11. This measurement is taken from the anterior part of the anterior palatine fossa to the posterior margin of the posterior palatine foramen. Average, 4 cms.

Chart 12. The average is taken as 6 cms.

Chart 13. The average is 8 cms. approximately.

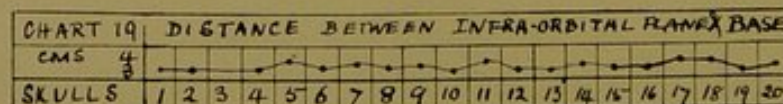
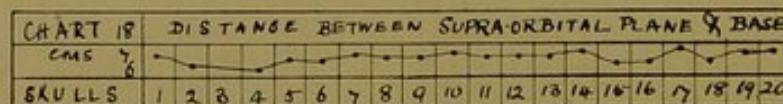
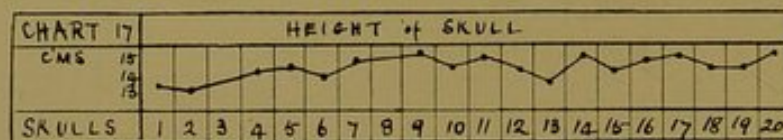
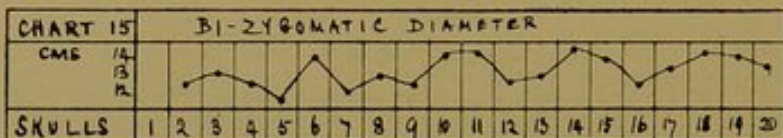
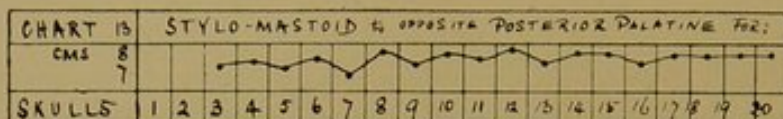
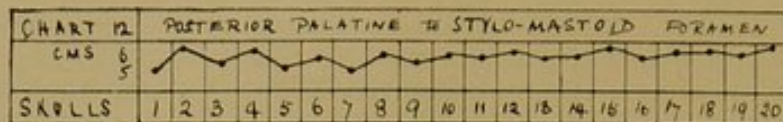


Chart 17. Compared with the average measurement given in chart 1, the average height of the skull to total length is about  $\frac{3}{4}$ . Variations are, however, considerable as are all variations of the vault in the adult skull.

Chart 18. The measurement is taken from a point half-way between the level of the hard palate and the alveolar margin, to the supra-orbital plane.

Chart 19. The measurement is taken from the same level as that in chart 18.

Chart 20. Average, 3.5 cms., the width of orbit being equal to its height.

Chart 21. Average, 2.5 cms. between the inner margins of the orbits.

Chart 22. Average, 2.5 cms.

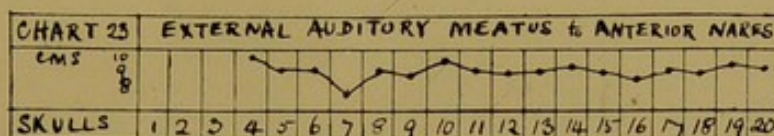
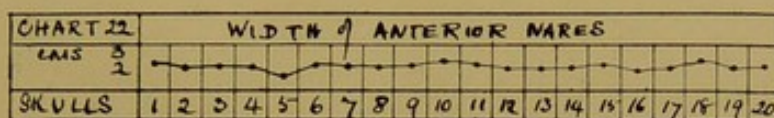
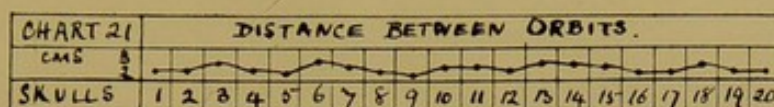
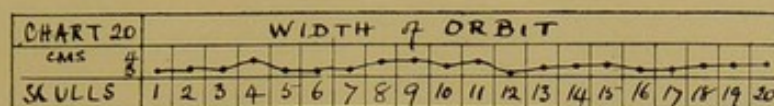


Chart 23. Average, 9.5 cms. This is taken on the lateral aspect, from the posterior margin of the external auditory meatus to the anterior margin of the nasal process of the superior maxilla, in a line parallel with the infra-orbital plane. It is remarkably constant, and is approximately equal to the anterior half of the antero-posterior diameter of the base of the skull. (Compare chart 6.)









