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THE OCCIPITAL LOBE IN THE BRAIN OF THE CHINESE WITH SPECIAL REFERENCE TO THE SULCUS LUNATUS

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INTRODUCTION

The important part which the sense of vision has played in the evolution of man makes it a matter of peculiar interest to investigate and compare the occipital region in the brain of the different races of mankind. Not only has Elliot Smith (9) revealed to us the probable path which man has trod in his upward march, and the rôle which vision has played in this advance; but also he has given us, by his investigations into the brain of the primates, the first clear knowledge of the homologies that may be instituted between the sulcal pattern of the human brain and that of the anthropoid apes. By the identification of the "Affenspalte" in the human brain (1) and by clearly distinguishing the difference in nature between the anterior and posterior calcarine sulci (5) he has paved the way for a more definite understanding of the differences that exist in the races of mankind in this important region.

It has been my good fortune, since coming to Hongkong, to have examined a very large number of Chinese brains in the fresh condition, as well as in the preserved state; and the present research is founded on the examination of over 400 specimens. While it is unlikely that this heterogeneous group represents a pure race, the features of the occipital region differ, in certain particulars, from anything hitherto recorded, and suggest that the departures from the recorded types are explainable on the grounds that there is such a thing as a Mongoloid type of brain; and that in all probability this type is distinctive.

The most outstanding feature in the occipital region of the brain in the anthropoids is the "Affenspalte," or sulcus lunatus occipitalis. Its frequent, if not universal, presence in the human brain has been pointed out by Elliot Smith (1); and his claim that this sulcus in man is the definite homologue of the sulcus lunatus in the anthropoid apes has been almost universally accepted. The present work on the brain of the Chinese can leave no doubt as to the correctness of his findings. Hulshoff Pol (10) and (11), however, would dispute his interpretation on the ground that he has not produced confirmatory embryological evidence, and would suggest that the older description of Gratiolet, with modification, should be retained. The condition of affairs in the brain of the Chinese would indicate that Pol has not examined the brains

of other races than the European, and that he has not looked for his confirmatory embryological evidence in the embryos of such a race as the Egyptian or the Chinese. Disagreement will also be found with his statement that "Elliot Smith's description is so vague that each sulcus on the occipital lobe can be taken for the sulcus lunatus."

The precision of Elliot Smith's description(6), not only of the sulcus lunatus, but also of such sulci as the sulcus paramesialis and the sulcus praelunatus, has made the interpretation of the brain of the Chinese so easy.

The Sulcus Lunatus

In the course of its evolution, the occipital lobe alters in its general appearance so far as the form of the various sulci is concerned, but the identity of these sulci remains apparent, not only in the brain of the apes, but also in the majority of human brains. The part played by the sense of vision in the attainment of the higher intellectual powers is expressed in the extent of the expansion of those areas of the cerebral cortex which Elliot Smith has termed para- and peristriate(6). This expansion around the periphery of the striate cortex causes a rolling back of the occipital operculum, and the consequent exposure of the sulci found on the anterior wall of the fossa lunata. In some cases in the orang outan this rolling back exposes the dorsal part of the sulcus parieto-occipitalis, but the sulcus occipitalis transversus remains hidden from view.

In the most primitive types of human brain thus far described, the rolling back has been continued a step further, and has brought about the full exposure of the sulcus occipitalis transversus on the surface, separated from the opening of the fossa, or sulcus lunatus, by a transverse gyrus of variable width. Retzius(12) has depicted a human brain in which the outer limb of the sulcus occipitalis transversus reaches the sulcus lunatus, but has failed to recognise the identity of the sulcus lunatus, regarding it as a "Halbringform."

Fig. 1 depicts the form and relations of the right sulcus lunatus (Sulc. Lun.) in the orang outan. It is seen to be a curved sulcus extending from the mesial almost to the tentorial border; the posterior lip of the operculum limits the stria of Gennari: laterally it is associated with a short horizontal sulcus—the sulcus praelunatus (*S. Pl.*). Within the concavity of the sulcus lie the Y-shaped sulcus occipitalis superior (*S.O.S.*) and the sulcus occipitalis inferior (*S.O.I.*). The sulcus occipitalis transversus is completely hidden on the anterior wall of the fossa lunata.

Such are the characters by which the sulcus lunatus is to be recognised (Davidson Black(13)).

Fig. 2, taken from the right hemisphere of a Chinese child of three years, reveals a configuration of sulci that differs from that seen in the orang outan only in minor details. It illustrates the most primitive type of human brain so far described. The sulcus lunatus is of somewhat different shape, and is not so extensive as it is in the orang; but it is nevertheless a prominent

feature of the occipital region, whose identity must be regarded as established by the fact that the posterior lip forms a well-marked operculum and that this lip exactly limits the stria of Gennari. The point of junction of the sulcus paroccipitalis (*S. Paro.*) with the sulcus occipitalis transversus (*S.O.T.*) is in great part hidden from view. The submergence, however, is not complete, for the ends of the two limbs of the transverse occipital sulcus can be seen emerging from under cover of the operculum. Fig. 3 gives an idea of the appearance of the specimen with the operculum drawn back. Associated with the *inner portion* of the sulcus lunatus, the sulcus paramesialis is seen passing forwards and inwards to join the sulcus parieto-occipitalis: laterally the sulcus praelunatus (fig. 2, *S. Pl.*) passes forwards from the *outer portion* of the sulcus lunatus towards the inferior parietal lobule: and finally, within the concavity of the sulcus are found the sulci occipitalis superior et inferior (*S.O.S.* and *S.O.I.*).

Every criterion for identifying the sulcus lunatus is fulfilled; but in order to dispel any doubt which may be raised from the embryological evidence, fig. 4 is given to show the brain of a Chinese embryo, in which the sulcus lunatus is plainly seen.

The expressions "inner and outer portions of the lunate sulcus" have been used above. On drawing back the operculum, one sees, not only in the human brain, but also in the brain of the orang, that, in the depths of the folding which forms the operculum, the inner portion of the sulcus lunatus is separated from the outer portion. The inner segment lies on the posterior wall of the operculum and differs from the outer portion in that it bears a different relation to the stria of Gennari. It is a sulcus which posteriorly lies within the striate area and anteriorly lies in front of it (fig. 3). It is connected with the sulcus paramesialis. Very frequently the cortex that separates the two elements comes to the surface; and then there appears a triradiate sulcus on the mesial border consisting of the inner portion of the sulcus lunatus and the sulcus paramesialis. The strip of cortex is the "pli de passage supérieur of Gratiolet." The very feature which Pol would make use of to disprove Elliot Smith's work becomes a most useful guide for homologising the sulcus lunatus. I propose to name this inner portion the "pars medialis sulci lunati" (figs. 6, 10, 11, 24, 25 *b*, 26 and 27).

Fig. 5 gives the appearance of sagittal sections taken through the lines *a–b* in figs. 1 and 8. In these sections the pars mesialis sulcus lunatus is seen on the posterior wall of the fossa.

The meaning of the arrangement of the sulci in fig. 6, now becomes apparent. This brain was taken from a Chinese child, four years of age, who had a complete transposition of the viscera. The sulcus occipitalis transversus is completely hidden on the anterior wall of the lunate fossa. The pars medialis sulci lunati is a separate element joined to the sulcus paramesialis. The sulcus lunatus proper might readily be confused with the sulcus occipitalis transversus. It is shown as a crescent-shaped sulcus lying obliquely across the occipital region. There can be no doubt, however, about the identity. The

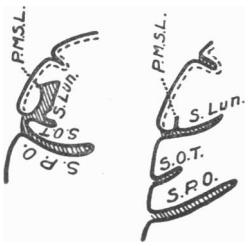


Fig. 5.

Fig. 4.

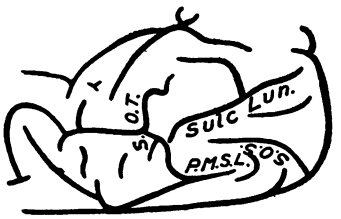


Fig. 3.

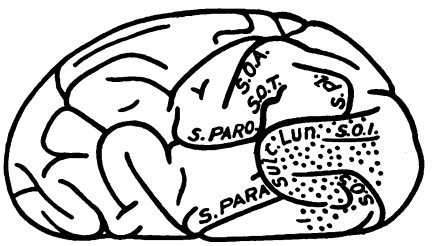


Fig. 2.

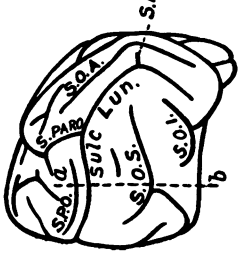


Fig. 1.

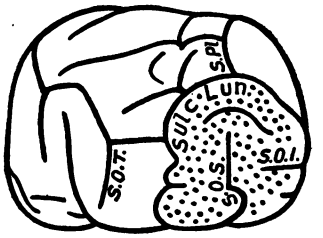


Fig. 9.

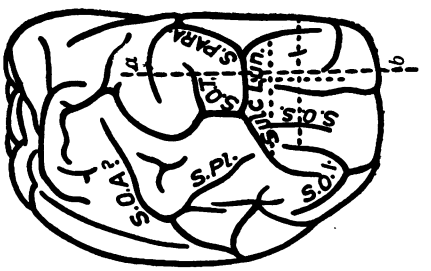


Fig. 8.

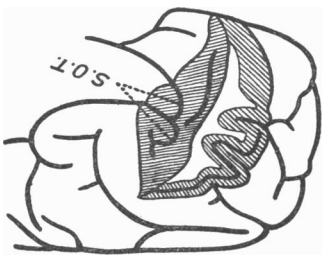


Fig. 7.

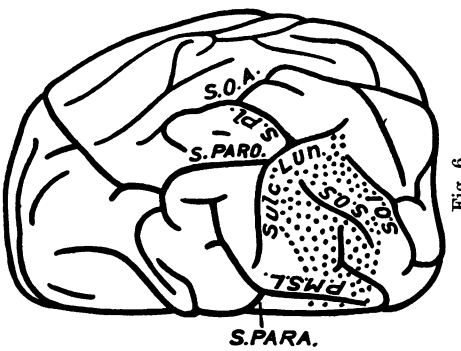


Fig. 6.

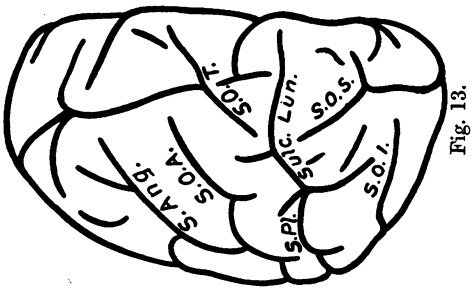


Fig. 13.

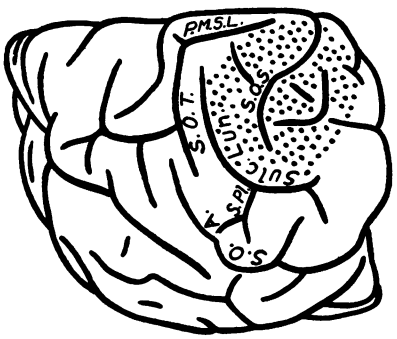
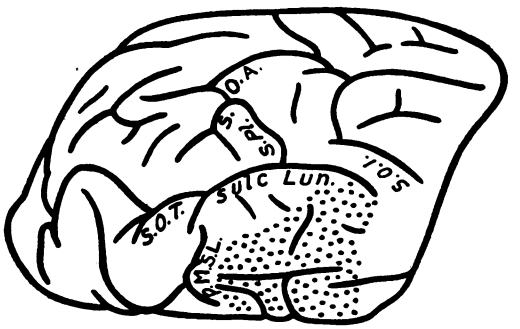


Fig. 12.



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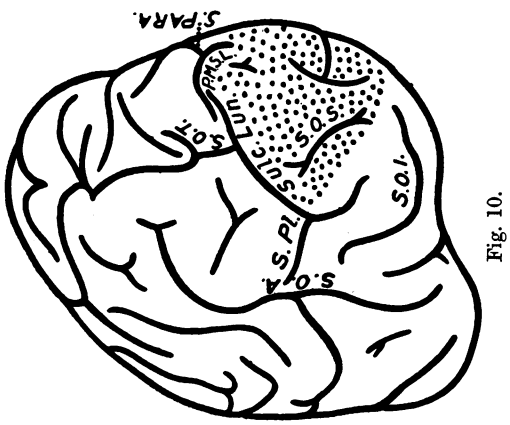

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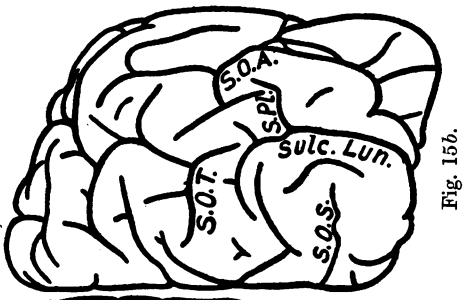


Fig. 15*b*.

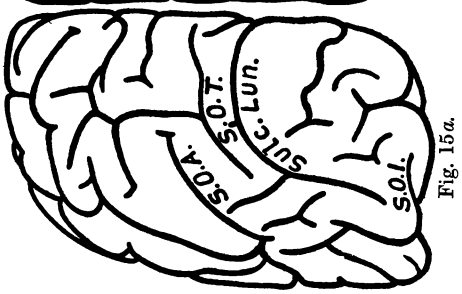


Fig. 15*a*.

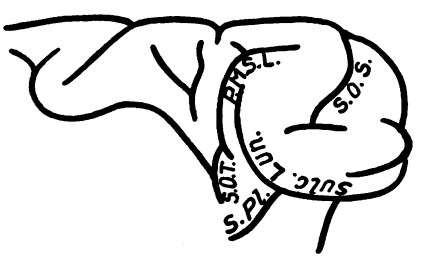
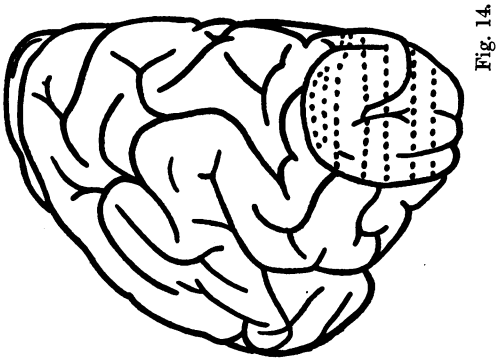


Fig. 14.



striate cortex is definitely limited by the posterior lip of the sulcus (a relationship which is never found in the case of the transverse occipital sulcus). The posterior lip forms a well-marked operculum which covers a considerable area of cortex; the sulcus praelunatus is typically arranged, passing forwards to join the sulcus occipitalis anterior (*S.O.A.*, frequently described as the termination of the sulcus temporalis medius); finally on the anterior wall of the fossa, the sulcus occipitalis transversus is quite apparent. At first sight the outer limb of the latter sulcus appears to be continuous with the sulcus praelunatus; such is not the case, however, for they are separated by a narrow submerged gyrus. This point is important, for the normal relation of the outer limb of the sulcus occipitalis transversus is to lie between the sulcus praelunatus posteriorly and the sulcus occipitalis anterior anteriorly (fig. 7).

It will be seen from the description of the series of brains in this paper that the sulcus lunatus commonly exists in one or other of the forms described above. We are enabled, therefore, to make a classification of the occipital region for comparative anthropological purposes. This classification is based on the form and relations of two sulci—the occipitalis transversus and the lunatus.

Group 1 A comprises those specimens in which the sulcus lunatus proper is continuous with the pars medialis sulci lunati as a fully curved opercular sulcus; and in which the sulcus occipitalis transversus is completely buried on the anterior wall of the fossa lunata (fig. 2).

Group 1 B comprises those specimens in which the pars medialis sulci lunati is separated from the sulcus lunatus proper, revealing the "pli de passage supérieur"; and in which the sulcus occipitalis transversus is completely buried (figs. 6 and 7, *S.O.T.*).

I have seen six cases belonging to Group 1, in approximately 400 brains.

One does not find an abrupt change from the condition in which the sulcus occipitalis is buried to that in which it lies completely free anterior to the sulcus lunatus. As would be expected, the sulcus occipitalis transversus has a tendency to lag behind on the anterior wall of the fossa. Elliot Smith (10) (figs. 2 and 4) depicts one case in which the outer limb is overlapped by the operculum and one in which the inner limb is overlapped. In the Chinese it is more often the outer limb which is overlapped and this overlapping always takes place in the area of the sulcus lunatus proper (figs. 8, 9, 10 and 11).

The inner limb is not so frequently found on the anterior wall of the fossa and, when it is hidden, one almost invariably finds that it is to the pars mesialis sulcus lunatus that it is attached (figs. 12 and 14).

I propose to institute two groups for these types, to conform with the grouping of the completely buried forms.

Group 2 A comprises those forms in which the sulcus lunatus is complete, and in which the outer limb of the sulcus occipitalis transversus is on the anterior wall of the fossa. *Group* 2 B comprises the forms in which the pars mesialis sulcus lunatus is separate—in other words the "pli de passage

supérieur" comes to the surface, and the outer limb is joined to the sulcus lunatus proper.

Groups 3 A *and* 3 B differ from Groups 2 A and 2 B in that it is the inner limb of the sulcus occipitalis transversus which is covered (figs. 12 and 14).

In fig. 12 (brain 126) we see an example of the type included in Group 3 B. The apparent backward extension of the sulcus occipitalis transversus is explained. Davidson Black, in a note on the sulcus lunatus in man, says:

On the right side (fig. 3) the caudal end of the interparietal sulcus (*B.N.A.*) is joined to a furrow which passes in a sagittal direction behind the mesial edge of the sulcus lunatus. In other words, the sulcus occipitalis transversus does not lie wholly in front of the lunate sulcus as is usually the case.

I have quoted this in full as it is of importance to appreciate the fact that the sulcus occipitalis transversus always does lie anterior to the sulcus lunatus. In the specimen depicted by Blake, the sulcus which he regards as the sulcus occipitalis transversus is the pars medialis sulci lunati, which is joined to the inner limb of the sulcus occipitalis transversus. It is a specimen belonging to Group 3 B.

The remaining types of occipital lobe have the one feature in common, that the sulcus occipitalis transversus is separated from the sulcus lunatus by a transverse gyrus of variable width. Two groups are to be recognised—firstly, *Group* 4, in which the sulcus lunatus is readily distinguishable, either in a complete form as in Groups 1 A, 2 A and 3 A forming the *Group* 4 A; or in which the pars medialis is a separate element with the exposed "pli de passage supérieur"—*Group* 4 B; and secondly, *Group* 5, in which the identity of the sulcus lunatus is not readily recognisable.

It is unnecessary to add anything to what Elliot Smith has already written on the form and relations of the type belonging to Group 4 A. It is desirable, however, to reproduce, for purposes of record, some typical examples of this group (figs. 13, 15*a*, 16, 17, 18, 20*a*, 20*b*, 21*a*, 22*b*, 23*a* and 23*b*).

Group 4 B likewise requires no description. It is illustrated in figs. 15*b*, 21*b*, 24, 25*b*, 26 and 27.

Group 5. In many cases the pattern of the lateral occipital region closely approximates to the pattern shown in European text-books, that is, the identity of the sulcus lunatus is obscured. The series of brains which I have had the opportunity of examining is so complete in all its stages that the homologies of the sulci are revealed, and the ape-like forms can be harmonised with these forms in which no occipital operculum is present. Before describing these stages, however, it is necessary to fix and homologise the more constant and conspicuous landmarks. These landmarks are closely related to the system of sulci which have arisen from the parallel sulcus, so that the inclusion of some of the sulci in the inferior parietal lobule is necessary.

The first sulcus to be considered, on account of its constancy in the brain of the Chinese and the anthropoids, is the sulcus praelunatus. This important landmark acts as an almost infallible guide to the sulci on the lateral surface.

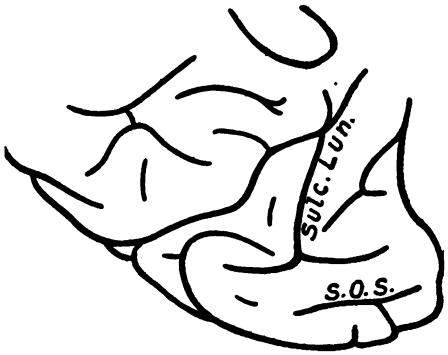


Fig. 19.

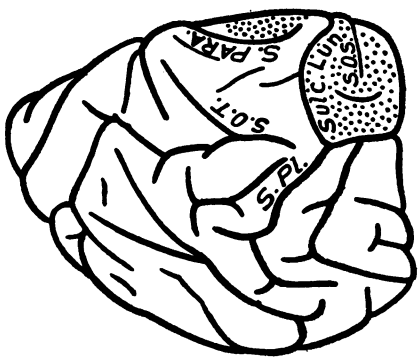


Fig. 18.

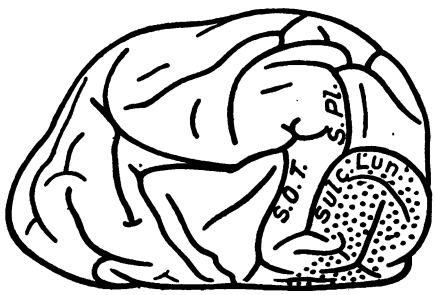


Fig. 17.

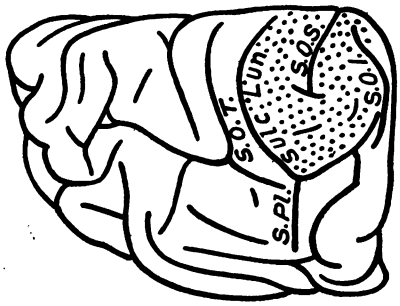


Fig. 16.

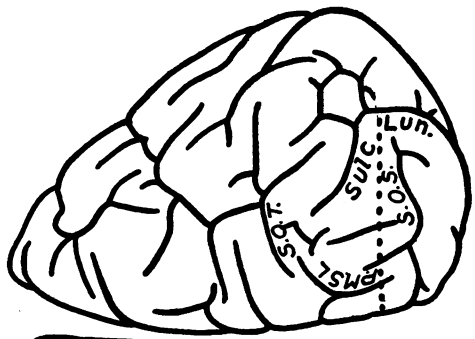


Fig. 21*b*.

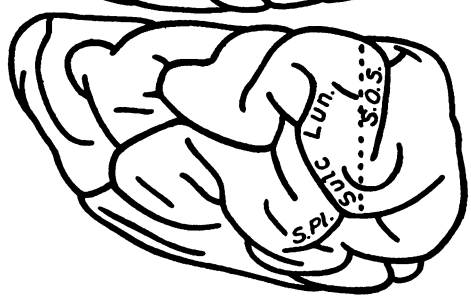


Fig. 21*a*.

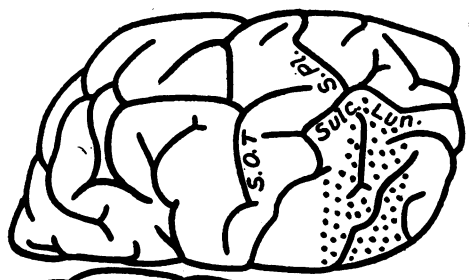


Fig. 20*b*.

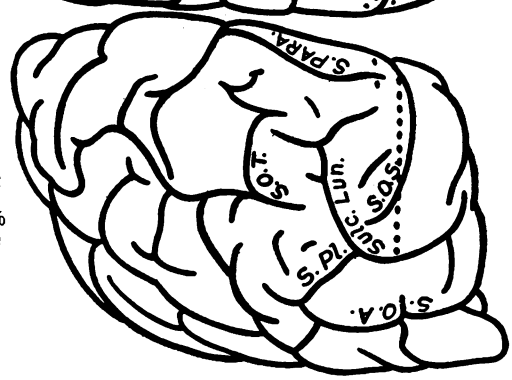


Fig. 20*a*.

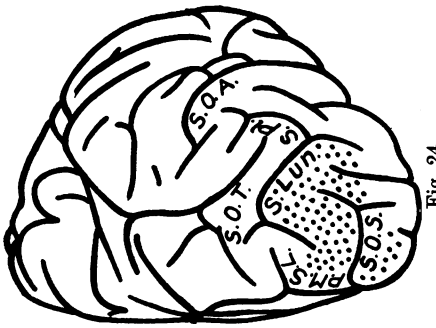
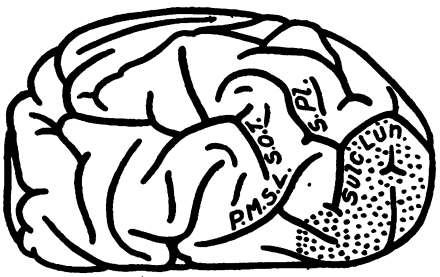


Fig. 24.



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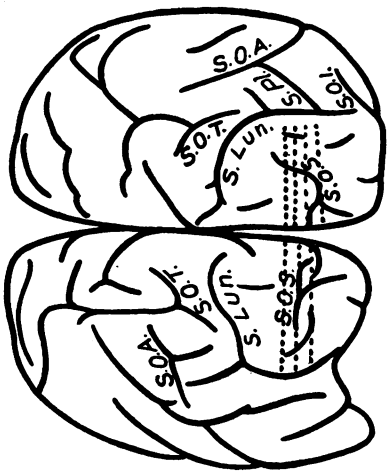

Fig. 23*b*.

Fig. 23*a*.

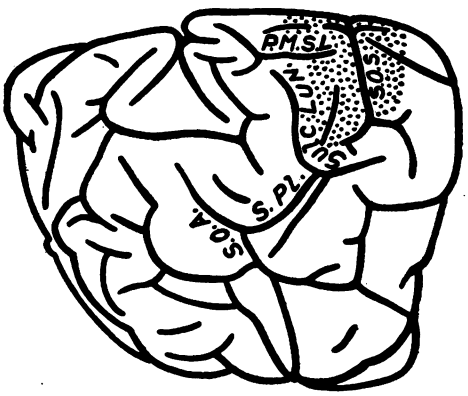

Fig. 26.

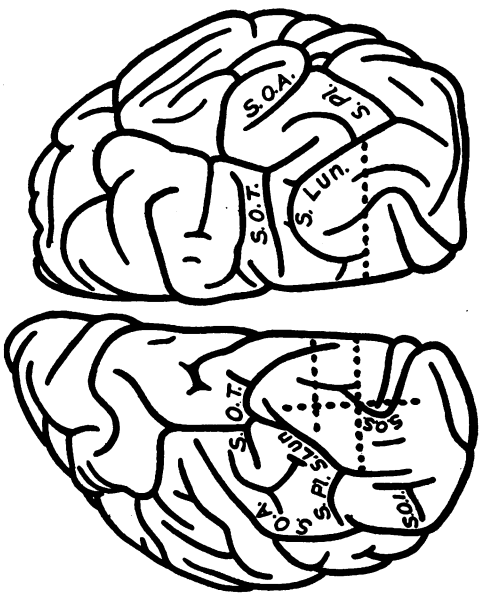

Fig. 22*b*.

Fig. 22*a*.

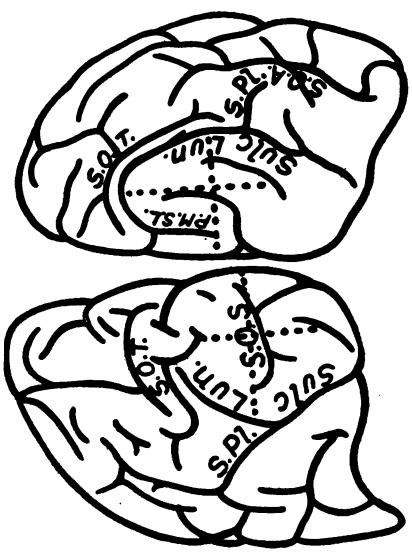

Fig. 25*b*.

Fig. 25*a*.

Elliot Smith(1) first refers to it in the Egyptian brain, and there appreciated the fact (p. 82) that the so-called lateral occipital sulcus of other anatomists is in reality a composite sulcus formed by a horizontal sulcus lunatus and the sulcus praelunatus. Although his evidence for this was not altogether conclusive, the series of brains under consideration fully confirm his opinion. It is a fortunate circumstance that in many of the brains the horizontal sulcus lunatus limits the striate area (figs. 26, 28 and 30). In this series the complete evolution of the lateral occipital sulcus is seen. It is not therefore strictly accurate to designate the sulcus occipitalis lateralis either as the sulcus praelunatus or lunatus; and so, it would seem preferable to retain the old term of sulcus occipitalis lateralis, understanding thereby the composite sulcus. The "plis de passage" of Gratiolet now become apparent; one can harmonise the older, purely descriptive, terminology with that which takes into account the evolution and physiology of the region, and there exists no reason for denying the homology of the sulcus lunatus in accepting the presence of these "plis de passage."

The sulcus praelunatus passes anteriorly towards a vertical sulcus which is frequently described as the sulcus temporalis superior. This name gives a wrong impression of its identity. It is the sulcus occipitalis anterior (*S.O.A.*). The sulcus temporalis superior, if by that term is meant the homologue of the parallel sulcus, normally ends, in the apes, by arching over the Sylvian fissure. In Quain's *Anatomy*(14), fig. 288, p. 300, a picture of the left cerebral hemisphere of the chimpanzee is given. It shows, arising from the parallel sulcus, a vertical sulcus which is the sulcus in question. It arises in the angle formed by the sulcus occipitalis transversus and the sulcus paroccipitalis and passes directly downwards to the tentorial border, to come into close relationship with the sulcus occipitalis inferior; in fact it is frequently joined to it. It is to this vertical sulcus that the sulcus praelunatus may become attached. In the Chinese, the sulcus occipitalis anterior is sometimes a separate element from the sulcus temporalis superior. When it is joined therewith, it is joined by means of a short connecting piece in common with the sulcus angularis—a sulcus which Elliot Smith has shown to be distinct in its origin from the sulcus temporalis superior. The form and relations of the sulcus occipitalis anterior are shown in figs. 1, 2, 6, 8, 9, 10, 11, etc.

The sulcus occipitalis inferior (*S.O.I.*), although subject to considerable variability, is another important landmark, and in all probability is represented in all human brains. In the Chinese it is found very frequently in the same form as one sees it in the apes. In the gibbon, it is a horizontal sulcus lying along the tentorial border, extending from the concavity of the sulcus lunatus to the second temporal convolution. In the Chinese this form is frequently present (figs. 10 and 22*b*). In the higher apes (fig. 1) it assumes a T-shaped form. The upper limb of the T lies parallel with the lower end of the sulcus lunatus. The stem of the T arches forwards under the tentorial border, to appear again on the lateral surface and join the sulcus occipitalis

anterior (figs. 6, 8 and 26). The junction of the stroke of the T with the stem is, however, more commonly on the inferior surface, and the sulcus may become connected with the sulcus collateralis.

I have nothing to add to what Elliot Smith has written on the sulcus occipitalis superior. It is found in a great variety of forms, from the primitive

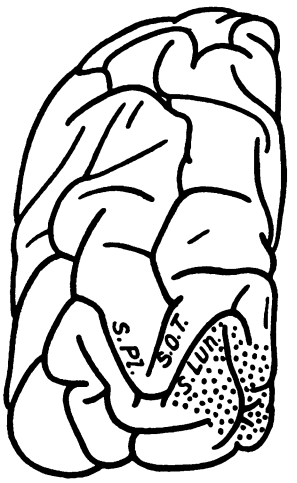

Fig. 28.

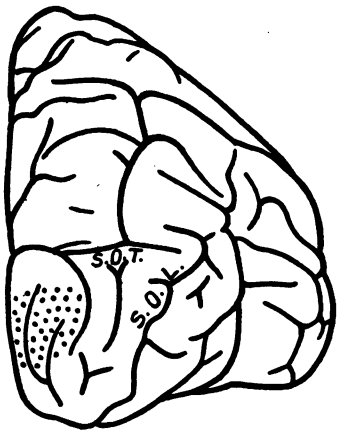

Fig. 29.

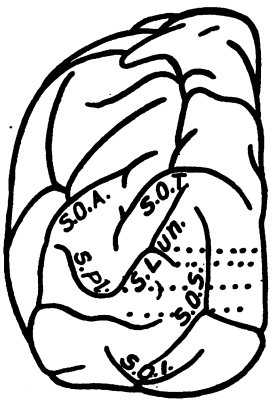

Fig. 30.

Fig. 31

condition seen in fig. 19 to the condition in which it is represented by rudimentary sulci.

It will be observed from the illustrations that, in the majority of specimens, the extent of the line of Gennari has been determined. In the Chinese, the lunate operculum definitely limits the striate area in a much larger percentage of cases than in other races so far described. In fully 75 per cent. of

cases it accurately delimits this area. Furthermore, the striate cortex is found in the great majority of specimens to extend for a considerable distance on to the lateral surface of the hemisphere.

GENERAL CONSIDERATIONS

The occipital region of the Chinese brain conforms to a type that reveals very clearly its agreement with a more primitive anthropoid type. The occipital region is similar in almost every respect to that of the higher apes, having a clearly marked sulcus lunatus extending well out on to the lateral surface of the brain, and, associated with it, are the paramesial, praelunate and transverse occipital sulci arranged in almost constant pattern.

Such variations as do occur are readily explicable. Our minds are hereby attracted to the significance of the brain as an organ of paramount importance in the interpretation of evolutionary problems.

The simple fact that the sulcus occipitalis transversus is overlapped by the operculum in the Anthropoid Apes and not in man has been unduly magnified as a distinctive feature. Those writers who, for this reason, would compare the brain of man directly with that of the Cebidae, thereby sacrifice the obvious means of explaining the presence of the paramesial and numerous other features in the occipital region, which are so clearly illuminated by a direct comparison with the Gorilla's brain (Elliot Smith on the brain of the Egyptian (1), (4), (5)).

The almost uniform arrangement of the sulci should also be of use in interpreting the more highly developed (perhaps specialised) brain of the European, and, no doubt, as further information of a functional character comes to hand, the meaning of a race retaining such primitive characteristics will become more and more apparent.

GENERAL SUMMARY

1. The brain of the Chinese shows that the sulcus occipitalis lunatus is normally present in its primitive condition. In the majority of cases, its posterior lip forms an operculum, and the stria of Gennari extends to the posterior lip of the sulcus.

2. The brain of the Chinese appears to be even more primitive, *i.e.* more directly comparable with the anthropoid brain, in the occipital region than the Egyptian. This is corroborated by the fact that the sulcus occipitalis transversus is to be found in many cases within the lunate fossa.

3. The constancy of the sulcus lunatus and its attendant sulci permits of a clearer definition of the sulci in the parietal region. The sulcus occipitalis anterior is recognised more definitely than heretofore.

ABBREVIATIONS IN FIGURES

(*For Description of Figures see Text.*)

S. Lun.	Sulcus lunatus occipitalis.	*S. Para.*	Sulcus paramesialis.
S. Paro.	,, paroccipitalis.	*S.O.T.*	,, occipitalis transversus.
S.Pl.	,, praelunatus.	*P.M.S.L.*	Pars mesialis sulcus lunatus.
S.O.S.	,, occipitalis superior.	*S. Ang.*	Sulcus angularis.
S.O.I.	,, ,, inferior.	*Sulc. Calc.*	,, calcarinus.
S.O.A.	,, ,, anterior.		

Dotted areas indicate extent of area striata.

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[Note. Professor Shellshear was unable to get access to the memoirs on the Chinese brain recently published in Europe. Of these the extensive monograph by Professor E. Kurz, "Das Chinesengehirn" (*Zeitsch. f. d. Gesamte Anatomie,* Bd. lxxii, Abt. 1, 1924) calls for special mention as a work filled with a mass of detail that leaves the problem discussed by Shellshear in a somewhat nebulous state. G. E. S.]