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THE FORE-BRAIN OF MACACUS.

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With Plates I and II.

The present article is the result of investigations upon the simian brain pursued by the writer during the winter of 1900 in the anatomical laboratory of Columbia University. A careful search of the bibliography of the simian brain failed to show any article dealing with the species in question. Here and there the writer came across rather poor drawings of the macaque brain but nowhere did he meet with any description thereof except in Flatau and Jacobsohn's Comparative Anatomy of the Central Nervous System of Mammals. In the Anatomical Museum of Columbia University the writer has had access to a sufficiently large number of macaque brains to render his observations fairly accurate.

Compared with the dog, Macacus presents many striking advances. A higher type of gyri and sulci, a well developed occipital lobe with a posterior cornu, a calcar avis, a prominent forceps major, and an enormously developed temporo-sphenoidal lobe are some of the points which will be discussed in the ensuing pages.

Whereas in the dog the ventral aspect of the encephalic segments lies almost entirely in the same plane, the brain of Macacus presents that convexity of the pons Varolii so marked in man. The pons of Macacus differs moreover from that of the carnivores in being actually larger than the medulla. In the carnivores the crura cerebri are plainly visible upon the base of the brain as two large bundles of fibres which extend from the pons and diverge to enter the cerebral hemispheres opposite

the optic chiasma. The crura of Macacus are not visible on the base of the brain. They are entirely hidden from view by the well-developed temporo-sphenoidal and the occipital lobes. In contradistinction to dog and man Macacus presents but a single corpus albicans, which occupies a mesial position. We naturally expect to find a well-developed olfactory apparatus in dogs; and such is the case, for the olfactory bulb projects beyond the hemispheres. The olfactory lobes, the bulbs and the olfactory tracts of Macacus are greatly atrophied. Compared with the dog the orbital surface of the frontal lobe has likewise retrograded.

The Hemispheres.

The growth backward of the body of the lateral ventricle in Macacus results in the formation of a posterior cornu, and gives us an additional lobe, the occipital. The occipital lobe is merely a differentiation of the posterior part of the parietal lobe. In Macacus it is very extensive, comprising about a third of the entire hemisphere. In man the occipital lobe comprises less than a sixth of the secondary fore-brain.

The hemispheres of Macacus are in contact with one another throughout their entire extent; even the apical portion of the frontal lobes are contiguous. In the dog the frontal apices are slightly separated, and the rounded posterior extremities of the parietal lobes diverge considerably to permit of the reception of the worm of the cerebellum between them. The entire hemisphere of Macacus is slightly curved from before backwards. This is most marked in the frontal lobe, where the apex curves sharply downwards in a hook-like manner. This curve is due to the non-development of the orbital surface. Externally the frontal lobes are flattened. The parietal and the occipital lobes are curved only slightly.

The arrangement of the fissures and the convolutions of Macacus closely resembles the condition met with in the human foetus. The numerous annectent gyri of the adult human brain renders it difficult to homologize the gyri of the adult brain with those of Macacus. The Sylvian, the Rolandic, the

inferior occipital, the par-occipital, the calloso-marginal, and the calcarine fissures divide the hemispheres of Macacus into frontal, parietal, occipital, and limbic lobes. A brief description of these fissures is therefore desirable at this juncture.

The Sylvian fissure is oblique in direction. In man it is horizontal, in carnivores almost vertical. It starts at the base of the brain, separating the orbital surface of the frontal from the temporal lobe. At first it proceeds laterally, then obliquely upwards and backwards, and finally terminates by joining the parallel fissure. In one specimen of Macacus nemestrinus under observation, the Sylvian fissure did not join the temporo-sphenoidal. Owing to the non-development of the orbital surface of the frontal lobe, the sylvian fissure in Macacus rhesus has no anterior limb. In Macacus nemestrinus, however, there exists a small rudimentary fissure occupying the position of the anterior Sylvian limb, but not continuous with the Sylvian sulcus.

The fissure of Rolando is very similar in its course to that of man. It runs from just below the great longitudinal fissure and curves sharply forwards and downwards. Before its termination, just above the mesial portion of the Sylvian fissure, the fissure of Rolando curves slightly backwards.

The par-occipital fissure runs sinuously from the great longitudinal fissure almost to the inferior margin of the hemisphere. Externally it is hidden from view by the growth forward of the occipital lobe. This growth forward of the occipital lobe results in the formation of a fissure, the "Affenspalte." This fissure, called by some the external occipital sulcus, is peculiar to Quadrumana. Upon drawing aside the "Affenspalte" we find lying in its floor two annectent gyri belonging to the par-occipital fissure. The par-occipital fissure is joined by the parallel and the intraparietal sulci.

The inferior occipital fissure extends from the posterior margin of the occipital lobe almost to the parallel fissure. It is curved forwards and upwards, and passes just below the "Affenspalte."

The calcarine fissure lies upon the mesial aspect of the

occipital lobe. It separates the temporal lobe from the occipital. At its origin it consists of two parts, an upper limb which arises from the superior margin of the occipital lobe and a shorter, lower limb which commences a little below the centre of the occipital lobe. These two limbs unite midway between the upper and the lower margins of the cerebrum. The calcarine fissure then runs at first downwards and forwards to the base of the hemisphere. It then passes forwards and slightly upwards, and terminates in the dentate fissure.

The calloso-marginal sulcus extends from the middle of the great longitudinal fissure almost to the apex of the frontal lobe. At first it curves downwards, then courses directly forwards, and finally curves upwards to terminate in the great longitudinal fissure. Before curving upwards it gives off a short inferior limb.

The Frontal Lobe.

The frontal lobe presents three surfaces, external, internal and orbital. The external surface is bounded inferiorly by the Sylvian fissure and posteriorly by Rolando. The external surface presents two fissures, the precentral and the horizontal. The precentral fissure is vertical in direction, and lies midway between the apex of the lobe and the fissure of Rolando. Superiorly it terminates by dividing into an anterior and a posterior limb.

The horizontal fissure lies a little posterior to the apex of the frontal lobe. It runs at right angles to the precentral sulcus. Posteriorly it curves slightly upwards.

The precentral and the horizontal fissures divide the frontal lobe into three convolutions. Of these the most posterior one corresponds exactly to the ascending frontal gyrus of man being bounded anteriorly by the precentral sulcus, inferiorly by Sylvius and posteriorly by Rolando. Just what the remaining two gyri are is difficult to say. BISCHOFF declares that in the gorilla and the orang Broca's convolution is but ill-developed; and according to PANSCH the third frontal convolution is absent in all other apes. If PANSCH be correct in his

theory we may homologize the upper frontal gyrus of Macacus with the first frontal of man, and the remaining lower gyrus with the second frontal.

The mesial aspect of the frontal lobe presents the marginal gyrus enclosed by the calloso-marginal fissure. The gyrus fornicatus is continuous with that portion of the frontal lobe which in man is known as the precuneus.

We have already noted the concave non-developed orbital surface of the frontal lobe.

The Parietal Lobe.

The parietal lobe has two surfaces; an external one bounded anteriorly by Rolando, inferiorly by Sylvius, and posteriorly by the "Affenspalte," and a mesial surface which is continuous with the gyrus fornicatus. The external surface presents the intra-parietal fissure. This sulcus lies between the fissure of Rolando and the external occipital sulcus. It starts a little posterior to the fissure of Rolando, and passes upwards and backwards. Then it curves upon itself, and terminates in the par-occipital sulcus. The intra-parietal fissure was originally composed of three distinct fissures, a superior, an inferior, and a horizontal parietal sulcus. This condition is still evident in the adult human brain where the three parts of the intra-parietal sulcus are separated from one another by numerous annectent gyri.

The external surface of the parietal lobe presents two gyri, a superior and an inferior parietal gyrus. The superior parietal gyrus represents the ascending parietal and the superior parietal convolutions of man. The inferior parietal gyrus may be divided into supramarginal and angular convolutions. The supramarginal is bounded anteriorly by the intra-parietal sulcus, posteriorly by the parallel fissure, and inferiorly by the fissure of Sylvius. The angular is bounded in front by the temporo-sphenoidal sulcus, below by the inferior occipital, and behind by the external occipital.

Temporo-Sphenoidal Lobe.

This lobe is very highly developed in Macacus. Its external surface presents the parallel fissure which is the most extensive sulcus of the cerebrum. It starts near the apex of the temporal lobe, and extends almost to the great longitudinal fissure; and there it joins the parieto-occipital fissure. Inferiorly it curves slightly forward; while superiorly it curves slightly backwards. The parallel fissure divides the temporal lobe into an upper and a lower gyrus. The lower gyrus is continued on to the base of the lobe. The superior convolution lies below the supramarginal gyrus. It is bounded anteriorly and above by the Sylvian fissure, and posteriorly and below by the parallel fissure. The base of the temporo-sphenoidal lobe is divided into two convolutions by the collateral fissure. This sulcus runs almost parallel with the inferior margin of the temporal lobe. It extends from within a short distance of the posterior temporal pole almost to the apex of the lobe. The collateral fissure forms the lower boundary of the hippocampal gyrus.

The Occipital Lobe.

As in man, the occipital lobe of Macacus presents an external, an internal and a basal surface. Externally with the exception of the superior occipital sulcus the occipital lobe is entirely smooth. The superior occipital fissure runs at right angles to the external occipital fissure. Externally the occipital lobe is separated from the parietal by the par-occipital fissure. The inferior occipital fissure separates the occipital from the temporal lobe. The mesial surface of the occipital lobe presents the cuneus, bounded in front by the parieto-occipital fissure and behind by the calcarine.

The Limbic Lobe.

The limbic lobe is bounded above by the calloso-marginal fissure, posteriorly by the rudimentary post-limbic sulcus, and inferiorly by the collateral fissure. This lobe includes the hippocampal and the fornicate gyri. The gyrus fornicatus

extends from the genu of the corpus callosum to the lower border of the splenium. Here it becomes the hippocampal gyrus. The latter is limited above by the collateral sulcus. In Macacus as in man the hippocampal gyrus forms a convolution of the temporal lobe, and is fused with the rest of hemisphere. In the brain of the sheep this is not the case; the hippocampus has no connection whatsoever with the exterior of the brain. In QUAIN'S "Anatomy of the Human Brain" BEEVOR is quoted as saying that the hippocampus major of apes receives no fibres whatsoever from the lyra of the fornix. To determine this point I carefully dissected two brains of Macacus and found in both a distinct band of fibres running from the lyra of the fornix to the hippocampus major,

The island of Reil in Macacus consists of two convolutions derived from the orbital surface of the frontal lobe. As in man the insula is overlapped by the operculum, and is thus invisible on the exterior of the undissected brain. In carnivores owing to the non-development of a large temporo-sphenoidal lobe, no insula exists.

The Lateral Ventricles.

The lateral ventricles of Macacus are especially interesting owing to the enormous extent to which the posterior cornu is developed. This development is not uniformly attained by man. Numerous cases are on record where the posterior cornu has been of small size or rudimentary. In the past year I have seen two brains, one that of a child two years old, the other an adult brain of thirty years, in which the posterior cornu of the left side measured 1.5 cm. and 2 cm. respectively. The right posterior cornu was well-developed in both cases. The posterior horn of Macacus presents a well-developed bulb, but an ill-developed calcar avis. The anterior and the descending cornua present no features markedly different from those of man.

The corpus striatum of Macacus is remarkable in that the lenticular nucleus seems to exceed the caudate in size. As in man the lenticular nucleus consists of three parts, an outer

portion known as the putamen, and two inner divisions called the globus pallidus. In carnivores no such division exists.

The corpus callosum of Macacus is very short. It presents, however, a well-developed forceps major and a forceps minor. The nerves of Lancisi are also plainly discernible. These cannot be differentiated in the dog. The splenium of the corpus callosum sends off a thick bundle of fibres which fuses with the hippocampus of both sides and serves as a commissure between them.

The anterior commissure is more extensive than in carnivores. It runs into the temporal lobe. Its termination can be ascertained only by microscopic methods.

The Third Ventricle.

The cavity of the third ventricle is extremely small and narrow. This is due to the fusion across the median line of the large optic thalami, which are continuous with one another throughout their length except inferiorly. This fusion across the median line represents the middle commissure of man.

From this brief macroscopic study of the fore brain of Macacus we see that the simian brain closely resembles that of man; for Macacus seems to present most of the conditions existing in man, the sole difference in most instances being one of degree.

DESCRIPTION OF PLATES.

PLATE I.

Fig. 1. The external surface of the left hemisphere of Macacus rhesus.

Fig. 2. Mesial surface of left hemisphere of Macacus rhesus.

PLATE II.

Fig. 1. Mesial surface of the left hemisphere of Macacus nemestrinus.

Fig. 2. External surface of cerebrum of Macacus nemestrinus. Part of the occipital lobe has been removed to show the annectent gyri.

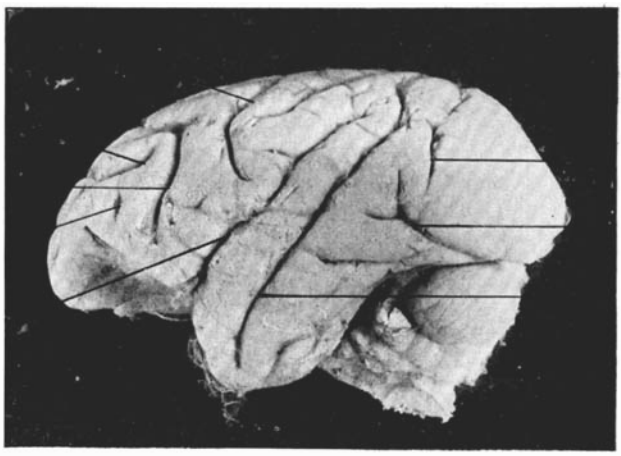
Rolando
Horizontal fissure
Precentral
Rudimentary fissure
Sylvius
Affenspalte
Inferior Occipital
Parallel fissure

Fig 1

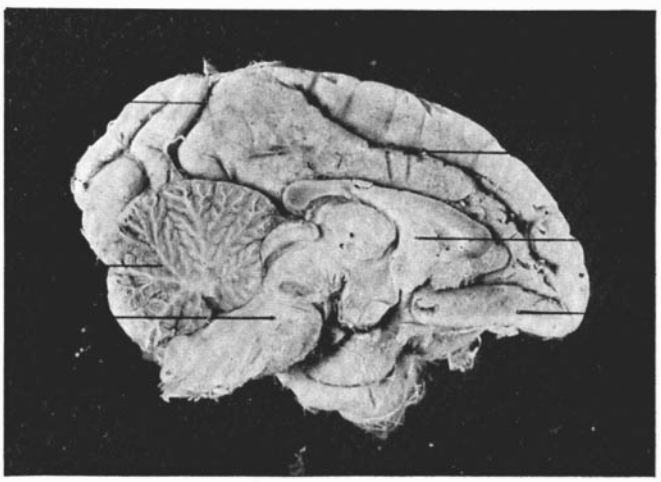
Occipital
Pons
Callosomarginal
Fornix
Frontal Lobe

Fig. 2

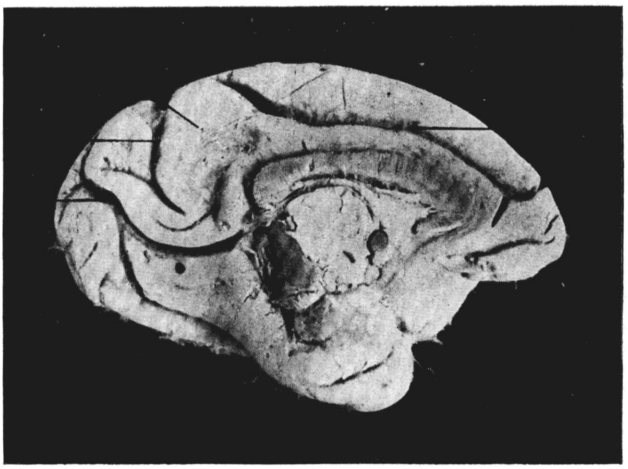
Precuneus
Occipital Sulcus
Calcarine fissure
Calloso-marginal

Fig. 1

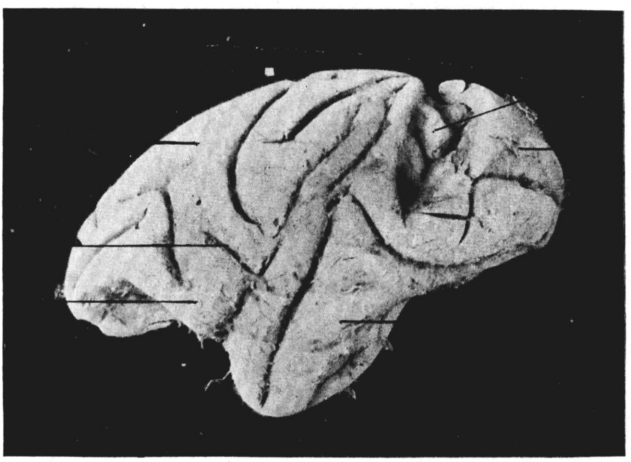
Ascending Frontal
Inf. transverse fissure
Second Frontal
Annectent gyri
Occipital Lobe
Temporal Lobe

Fig. 2