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CONTENTS.

The following papers were read:

Zoology. — *"On the development of the brain in Tarsius spectrum."* By Prof. TH. ZIEHEN of Berlin (Communicated by Prof. A. A. W. HUBRECHT).

(Communicated in the Meeting of September 24, 1904).

Owing to the kindness of Prof. HUBRECHT seven series of embryos of Tarsius spectrum were at my disposal, among them a sagittal series. With regard to the central nervous system of the adult animal I refer to two short papers published by myself, Anat. Anz. Bd. 22, N°. 24, p. 505 seq. and Mon. Schr. f. Psychiatrie u. Neurol. Bd. 14, p. 54 seq.

The first stages of development are only known to me from HUBRECHT's paper. In the youngest embryo the segregation of the two hemispheres has only just commenced. The next youngest embryo shows the hemispheres already developed, namely at the lower posterior periphery of the anterior vesicle. They are separated from this latter by a sulcus hemisphaericus which anteriorly forms a pretty deep and sharp groove but occipitally terminates in a shallow groove. The segmentation of the posterior brain (5 segments) is clearly shown especially by the youngest embryo.

The following stages are very similar to those of other mammalian orders. In frontal sections through the hind-brain the uncommon depth of the sulcus limitans in the distal parts is especially striking. Frontally it soon becomes smooth. A sulcus intermedius (Groenberg) is indicated. The inner and outer labial grooves ("Lippenfurchen") are present. The cerebellum consists of two symmetrical lamellae, one to the right and one to the left, joined by a thin and narrow medial part. On the outer surface of each lamella a broad medial longitudinal groove in the immediate proximity of the median part and a narrower but relatively deeper lateral groove are to be seen. Corresponding to these two grooves we find on the ventricular surface of each lamella two longitudinal ridges and three grooves (an unpaired sulcus medianus dorsalis, a sulcus medialis dorsalis and a sulcus lateralis dorsalis on each side). The roof of the mesencephalon is rather pointed and edged like a keel. The pharyngeal part of the hypophysis shows an almost compact appendix, extending backwards and downwards. Also two lateral continuations in a backward and downward direction of the ventricle of the mid-brain deserve notice. The chorioid fissure is already developed and shows some bulgings. The sulcus hemisphaericus has also become much more marked occipitally. The sickle-fold ("Sichelfalte") forms a sharp but shallow groove and is enclosed by the bifurcating ventricle of the fore-brain. The sulcus hemisphaericus lies at the right and left in close proximity of it. The Ammon fold (Hippocampal furrow) is still entirely absent. At a stage which for the rest has only little advanced, the shape of the fore-brain has already materially progressed in development. The sickle-fold is a deep groove. In its wall the Ammon fold is noticed to which corresponds on the surface of the ventricle a distinct Ammon ridge. In an occipito-parietal direction the sickle-fold reaches as far as the anterior limit of the mid-brain, basally it finally terminates smoothly in the lamina terminalis. The sulcus Monroi is very sharply marked. On one side it terminates smoothly in the neighbourhood of the stalk-fold of the optic vesicle and on the other side in the neighbourhood of the floor fold of the primary foramen Monroi (not in the foramen itself).

The above-mentioned appendices of the lumen of the midbrain have already become rudimentary. The characteristic enclosure of the cerebral part of the hypophysis by the pharyngeal part is met with here in a similar way as in other orders of mammals. The lamella of the cerebellum has grown thicker. Of the longitudinal grooves, it is only the sulcus dorsalis medialis and the sulcus medianus dorsalis that are well marked on the inner surface. On the outer surface the ridges and grooves have been almost entirely flattened out. The posterior longitudinal bundle, the spinal root of the trigeminus and the lower olive form already distinct prominences. The chorioid plexus of the fourth ventricle has already invaginated itself considerably. The differences in level of the fossa rhomboidea have already a little more flattened out. The sulcus intermedius is lacking, the sulcus limitans is distinct. The labial grooves have become flatter.

The next-following changements may be briefly summarised as follows:

a. The hemispheres show a deep groove corresponding to the thalamencephalon, vallis diencephalica. The medial wall of each hemisphere shows on horizontal section three ridges projecting towards the lumen of the ventricle, which we will denote by *R*, *S* and *T* in their order from before backwards. Between *S* and *T* we find, following up the series in a basal direction, a great diminution in the thickness of the ventricular wall (part *d*). In this thinner part and much nearer to *S* than to *T* the formation of the chorioid fissure occurs and the invagination of the plexus chorioideus ventriculi lateralis. *S* and *R* coalesce more and more. Meanwhile from the lower posterior part of the wall of the hemispherical ventricle the broad ridge of the caudate nucleus arises. The lateral ventricular wall shows only a very slight thickening, resp. elevation *N* in its posterior part, which at higher (i. e. more parietally situated) levels, together with the caudate nucleus marks a narrow slit and coalesces with the caudate nucleus at lower levels. Between the caudate nucleus and the ridge *T* there is a fold, which may be denoted by *r*. A very shallow prominence *P* is also shown by the lateral wall in its most anterior part. The further the series is followed in a basal direction the more conspicuously a short anterior portion is marked off on the medial hemispherical surface of the vallis diencephalica, which portion is not contiguous with the thalamencephalon, but is separated from the corresponding part of the other hemisphere by

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the primitive sickle fold only. Within reach of this portion we find now also a slight ridge projecting into the ventricle, which we shall here designate by Q for briefness' sake. To all these just mentioned prominences of the interior wall-surface correspond only very slight grooves of the exterior surface or none at all. Only the ridge S corresponds in future pretty accurately to a shallow groove S', which must be interpreted as the fissura hippocampi. This groove belongs to that part of S which is nearest the chorioid fissure and finally has an almost hook-shaped bend near the neighbouring lip of the chorioid fissure. The more in the following sections S is arched, the more also the fissura hippocampi is deepened, while at the same time all other ridges are levelled. Only the caudate nucleus remains entirely unchanged. On its surface a very slight groove is temporarily seen. The grooves ν and τ become gradually obliterated for the greater part, so that the caudate nucleus coalesces with P and T. The thinner part d of the medial wall does not coalesce with the caudate nucleus. So the bottom of the groove τ finally corresponds exactly to the border of d and T. When we progress still further in a basal direction, the first connection between the thalamencephalon and the hemispheres appears immediately below the bottom of the groove τ, i.e. in the former region T and rapidly increases first in an occipito-basal direction. At the same time the lamella d now seems to originate in the bend between the caudate nucleus and the optic thalamus.

In the following sections we find d more and more connected with the lateral wall of the thalamencephalon, i. e. with the optic thalamus itself.

The insertion of the lamella d seems to shift more and more towards the roof of the thalamencephalon and the lamella itself seems to become shorter. It is one of the most difficult questions of cerebral development whether this shifting and shortening of the lamella d and also the coalescence of the caudate nucleus with T and the lateral wall of the thalamencephalon must be interpreted as a secondary coalescence of originally separated parts. My histological investigations of Tarsius do not allow me to give a definite answer to this question. Still more basal sections show the disappearance of the chorioid fissure. Since d has in the meantime also disappeared, S passes immediately into the epithelial roof of the thalamencephalon or primary fore-brain. The groove-shaped longitudinal depression on the surface of the corpus striatum becomes a little more distinct. The fissura hippocampi resp. the fissura prima is pointed so that in the cross-sections the well-known picture appears, resembling a lance point. Also the roof of the median-mantle-slit which was at first formed by the folded roof of the thalamencephalon, now becomes sharply pointed. The fissura hippocampi or rather its lower lip marks pretty sharply, even after the separation of the hemispheres from each other, the point reached by the formation of the pallium. It is also very remarkable that *S* and *S'* *no longer exactly correspond to each other topographically*, but that *S'* becomes situated somewhat ventrally of *S*. Below *S* the medial wall of the frontal brain shows a second feeble prominence *U*. *U* and the caudate nucleus terminate in the medial respectively lateral wall of the ventriculus lobi olfactorii and in doing so grow smoother. After the disappearance of the fissura hippocampi the medial wall first remains quite undivided in many sections, but then (almost exactly in the corresponding place) the medial terminal part of the rhinal lateral fissure appears as a shallow groove.

β. The cavity of the thalamencephalon shows in its posterior parts two grooves, an upper one *κ*, which is continued in the lateral groove of the midbrain ventricle (aqueduct) and frontally very soon smoothes out, and a lower one *λ*, which can be traced as far as the region of the foramen Monroi. The latter one is accompanied during the anterior part of its course by a parallel groove *μ* of a slightly more basal situation. Further folds of the surface are temporarily observed within reach of the optic stalks and of the corpora mammillaria. I regret not to be able to decide whether *λ* or *μ* has to be interpreted as the sulcus Monroi; to me it seems more likely that *μ* deserves this designation.

The picture is materially completed by studying a sagittal series belonging to about the same stage of development (length of the embryo 11 mm).

In a section situated somewhat laterally of the medial plane, we find as follows:

The fossa mesodiencephalica is sharply marked. Before it and for a smaller part also in it, lies the long-stretched cross-section of the posterior commissure. A very shallow groove which I designate by *E* corresponds approximately to the frontal plane of the epiphysis. There is no objection to designating with v. KUPFFER (cf. v. KUPFFER in HERTWIG's Vergl. Entw. geschichte p. 95) as synencephalon the roof part between the fossa mesodiencephalica and *E*. The fossa praediencephalica is not sharply marked. It might be sought at the place where the invagination of the plexus chorioideus ventriculi tertii occurs. It must be emphasised that it remains doubtful whether this spot corresponds to the velum transversum of lower vertebrates.

The region above the invagination of the plexus is the posterior roof portion of the primary fore brain. Below the invagination of the plexus lies the lamina reuniens, the lower part of which corresponds to the lamina terminalis of the adult animal. Before the praeoptic recess we find on the basal inner surface a shallow transverse prominence, which is laterally prolonged into the central mass of the striated body.

This transverse ridge of which even in the median plane we can recognise indications, corresponds to the crus metarhinicum corporis striati of the human embryo, described by HIS [1]). Consequently it passes medially into the lamina terminalis. Only in somewhat more laterally situated sagittal planes we meet before the crus metarhinicum with a second transverse prominence, which sinks away into the olfactory lobe. I designate it as crus rhinicum corporis striati. It corresponds to the crus mesorhinicum of the human embryo. A crus epirhinicum is scarcely indicated. In my opinion it is only counterfeited by the fold of the lateral rhinal fissure. On the outer contour we find corresponding to the border of the crus metarhinicum and rhinicum a shallow groove, corresponding approximately to the posterior edge of the cappa olfactoria and also approximately to the anterior edge of the olfactory tubercle. It by no means corresponds exclusively, as HIS seems to assume, during its whole course to the crus rhinicum or mesorhinicum. I believe that its formation is essentially independent of the morphological condition of the striated corpus and has rather to be explained by thickening of the wall of the olfactory lobe by superposition of the olfactory ganglion (cappa olfactoria) on one hand and of the olfactory tubercle [2]) on the other. To this is added a sharp bend in the brain tube in a basal direction when it passes from the hemisphere to the olfactory lobe. Moreover we must bear in mind that the lumen of the ventricle, when passing from the hemisphere to the olfactory lobe, at first tapers very rapidly, but then again very slowly [3]). Especially at the base this behaviour is very conspicuous. Obviously this must result, quite independently of a thickening of the wall by the striated corpus, in a basal transverse groove. The designation "fissura mesorhinica" which HIS has given to this latter, does not seem to me appropriate under these conditions. I propose to speak of a *vallis* mesorhinica. A second transverse groove is found caudally of the

[1]) HIS, Die Entwickelung des menschlichen Gehirns während der ersten Monate. Leipzig, S. Hirzel, 1904. S. 61 (cf. also fig. 34, p. 56).

[2]) The two borders only coincide by chance and not accurately.

[3]) Die Entwickelung des menschl. Gehirns etc. Leipzig 1904, p. 54 and p. 60.

vallis mesorhinica behind the origin of the olfactory tubercle and before the region of the praeoptic (= optic) recess. I propose to denote it as vallis praeoptica, whereas His seems to look upon it as a continuation of his stalk-fold (my sulcus hemisphaericus) [1]). It also is brought about independently of the striated corpus by the bulging of the olfactory tubercle on one hand and of the region of the chiasma on the other. The niche in the ventricle corresponding to the olfactory tubercle is designated by His (at least in man) as the posterior olfactory brain in opposition to the olfactory lobe s. str., which he calls the anterior olfactory brain. To the posterior olfactory brain he reckons particularly also the substantia perforata anterior. Against the designation "posterior olfactory brain" I only object that it favours confusion with the lobus piriformis, i. e. with the posterior part of the rhinencephalon [2]).

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1) Cf. on this point also His, die Formentwickelung der menschl. Vorderhirns, etc. Abh. d. math. phys. Cl. d. Kgl. Sächs. Ges. d. Wiss. Bd. 15, fig. 32, p. 725.

2) Concerning the nomenclature in this region I would make the following remarks. All cerebral parts that lie basally of the fissura rhinalis (=ectorhinalis=rhinalis lateralis of many authors) I denote as rhinencephalon. As lobus olfactorius (=lobus olfactorius anterior of many authors) I designate in a purely topographical sense the anterior part of the rhinencephalon as far as it is quite separated from the lower surface of the pallium. For the posterior part of the rhinencephalon the designation "lobus piriformis" might be reserved, but it is more advisable to give up this name entirely. Part of the lobus olfactorius is covered with a microscopically sharply characterised formation, the so-called formatio bulbaris. This cover I designate as cappa olfactoria. From the developmental point of view it corresponds to the ganglion olfactorium of His. The separation of the lobus olfactorius and the pallium is exclusively brought about by the fissura rhinalis (lateralis). Hence we must also regard as a part of the fissura rhinalis the separating groove of olfactory lobe and frontal lobe which is visible in the median plane, i. e. I assume that the fissura rhinalis incises at the front as far as the median plane. The cappa olfactoria is marked off from the free surface, i. e. from the surface of the olfactory lobe that is not covered by the formatio bulbaris, by a limiting groove, the margo cappae olfactoriae. Laterally it is much more clearly marked than medially. In many animals (hedgehog, Echidna) the cappa olfactoria covers almost the whole olfactory lobe. The olfactory tubercle is also marked off against its surroundings by a shallow

Finally we mention as self-evident that in exactly medial sections all the just mentioned borders, grooves and prominences are almost entirely lacking.

Sagittal sections further prove concerning the mid-brain that at this stage it covers the isthmus to a relatively small extent, less e. g. than in a human embryo of 2 to 3 months. The cerebellum shows in sagittal sections still a horn-shaped form. Of the occipitally directed ridge, which is so characteristic for man, nothing is to be found yet.

The oldest of the embryos at my disposal had been dissected into a somewhat slanting frontal series. Here also nothing can be detected of a crus epirhinicum corporis striati. Notable is the considerable thickening of the wall in the basal portion of the medial ventricular wall. It only becomes distinct after the lateral ventricle and the ventricle of the olfactory lobe have already coalesced for some time[1]). The thickened lower portion and the not-thickened upper portion of the wall are separated on the inner surface of the ventricle by a very distinct groove which can be followed almost as far as the frontal plane of the terminal lamina. It has nothing to do with the marking off of the olfactory lobe, as it appears considerably later and also lies somewhat higher than the fissura rhinalis lateralis. In the same way it is entirely independent of the ammon fold, since it lies considerably lower than this latter. Microscopically it forms a pretty sharp basal limit for the pallium formation. Therefore I designate it as margo pallii medialis internus (v. also below). In the section where the third ventricle is visible for the first time, it appears as a paired structure; between the two terminal points of the ventricle a median groove incises into the ventricular roof (cf. above).

Special notice deserves the floor of the third ventricle. Its median groove forms a very sharp incision. The lateral parts of the floor rise, so to say, in three gradations. The most lateral prominence

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groove, the margo tuberculi olfactorii. This groove also is generally not so distinctly perceptible at the medial edge, on the other hand at the lateral and anterior edges it is well developed and hence has here often been designated as fissura rhinalis medialis s. entorhinalis. At the posterior edge, towards the substantia perforata anterior, it is generally rather shallow. When the cappa olf. reaches far backward, the anterior margo tub. olf. coincides entirely or partly with the margo cappae olf.

[1]) In what follows the series is supposed to be examined from before backward.

which at the same time is the broadest, proceeds from the crus rhinicum of the corpus striatum and forms in future the principal mass of this ganglion. The middle elevation corresponds to the crus metarhinicum of the corpus striatum. It disappears with the separation of the hemispheres. In the lamina terminalis it meets the homologous opposite prominence. It is interrupted by the anterior commissure. The most medial and smallest elevation only becomes visible before the lamina terminalis and is at first very flat; then it rises pretty steeply frontally but remains narrow. From the homologous opposite elevation it remains separated by the shallow median floor groove. Following the series farther in a frontal direction, the two hemispheres split finally within reach of the median groove of the floor and the most medial elevation coalesces before the foramen Monroi with the upper portion of the medial wall, corresponding pretty accurately to the margo pallii medialis internus.

From this description we must conclude that also this most medial elevation can by no means be interpreted as the crus epirhinicum in HIS' sense.

The optic thalamus projects in the following sections between the middle and lateral ridge just mentioned. More sharply developed than in preceding stages a longitudinal groove on the outer surface of the thalamencephalon (sulcus fastigialis thalami) is now visible dividing the pointed crest of the optic thalamus from the broad basal mass of this ganglion.

It is situated somewhat higher than the above mentioned groove $\varkappa$, which for the rest is now much less distinct. λ and μ are no longer clearly divided. Instead of them we find a broader groove, which doubtless must be designated as sulcus Monroi.

The hind brain presents no peculiarities.

Reviewing the whole of the peculiarities in the development of the brain of Tarsius that have been noted in the preceding pages, a far-reaching agreement with the development of the brain of the primates is obvious. The essential differences are sufficiently explained by the rather pronounced macrosmatic character of the brain of Tarsius. It is much more difficult to determine the relations of the Tarsius brain in the descending direction. Carnivores and Ungulates are out of the question. The development of the brain of Chiroptera is unfortunately too little known as yet but certain analogies are certain. Very great is also the agreement with the development of the brain of Rodents, only one must not consider the brain of the rabbit as the typical representative of the brain of Rodents, as is often done. As the rodent brain in its turn is not far distant in its development from the brain of the Insectivores, it is clear that the Tarsius brain shows unmistakable genetic relations with this latter also.

A more detailed account with figures will be published in the Handbuch d. Entwicklungsgeschichte edited by HERTWIG.

Mathematics. — *"On the equation determining the angles of two polydimensional spaces".* By Prof. P. H. SCHOUTE.

The problem which we wish to solve is the following:

"In a space S_n with n dimensions a rectangular system of coordinates $O\ (X_1\ X_2\ \ldots\ X_n)$ has been taken and with respect to this system a space S_p passing through O has been given by the equations

$$x_{p+i} = a_{1,i}\, x_1 + a_{2,i}\, x_2 + \ldots + a_{p,i}\, x_p\ ;$$
$$(i = 1, 2, \ldots, n-p)$$

supposing this space S_p to have with the space of coordinates $O\ (X_1\ X_2\ \ldots\ X_p)$ but one point O in common, the p angles $\alpha_1, \alpha_2, \ldots \alpha_p$ are to be determined between these two p-dimensional spaces."

By means of geometry we should set to work as follows. Suppose in the given space S_p a spherical space having O as centre and unity as radius and thus forming in S_p the locus of the points at distance unity from O; if this spherical space projects itself on the space of coordinate $O\ (X_1\ X_2\ \ldots\ X_p)$ as a quadratic space with the half axes $a_1, a_2, \ldots a_p$, we get

$$a_1 = \cos \alpha_1,\ a_2 = \cos \alpha_2,\ \ldots,\ a_p = \cos \alpha_p.$$

In an almost equally simple way the tangents of the demanded angles are connected analytically with the central radii-vectores of an other quadratic space. If P is an arbitrary point of S_p and Q its projection on the space of coordinate $O\ (X_1\ X_2\ \ldots\ X_p)$, then the angle $P\,O\,Q = \alpha$ is also determined by the relation

$$tg^2\, \alpha = \frac{OP^2 - OQ^2}{OQ^2} = \frac{\sum\limits_{i=1}^{n-p} (a_{1,i}\, x_1 + a_{2,i}\, x_2 \ldots + a_{p,i}\, x_p)^2}{\sum\limits_{i=1}^{p} x_i^2}.$$

If we consider in S_p the points P the coordinates of which are bound to the condition

$$\sum_{i=1}^{n-p} (a_{1,i}\, x_1 + a_{2,i}\, x_2 + \ldots + a_{p,i}\, x_p)^2 = 1 \ldots\ldots\ (1),$$