Citation:

On the development of the Cerebellum in Man (Second part), in:
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which we are *waiting for the cock to be free again*, is used to remove that which is deposited at the place intended for the liquid hydrogen. Thus it is not difficult to prepare from the commercial hydrogen large quantities of hydrogen with less than 1 pro mille of admixture.

Anatomy. — *"On the development of the Cerebellum in Man"*. (Second Part). By Prof. L. Bolk.

In the first part of this communication the development of the Cerebellum is described until the stage in which the sulci appear typical for the mammalian cerebellum. In this stage it is divided by the sulcus primarius into an anterior and posterior lobe. The first of these lobes is separated by three grooves into four lobules, corresponding with the lobuli 1, 2, 3 and 4 of the mammalian cerebellum. The posterior lobe is also separated by three grooves (sulcus praepyramidalis, fissura secunda and sulcus uvulo-nodularis) in four lobules, corresponding with the lobuli A (nodulus), B (uvula), C_1, (pyramis) and C_2 (declive + folium vermis + tuber vermis), which, with a few exceptions, are to be found in the other mammals. In these exceptions the sulcus praepyramidalis, which separates the lobuli C_1 and C_2, is missing, as in Erinaceus (Arnbäck Christie Linde), Notoryctes (Elliot Smith), Vesperugo (Charnock Bradley), Chrysochloris (Leche). In this case the posterior lobe is only built up of three lobules. The missing of the sulcus praepyramidalis in these cerebella of extremely simple construction gives rise to the supposition that this fissure is phylogenetically the youngest of the primary sulci of the cerebellum. This supposition is corroborated by the fact that in man the sulcus praepyramidalis is ontogenetically the last that appears.

After the development of these primary sulci, grooves appear characteristic for the cerebellum of the primates, and whose homologa are wanting in other classes of mammals.

In embryos of a length from 16 to 22 c.M. arises a groove on the posterior surface of each of the hemispheres, the lateral part of which is directed to the obtuse angle of the lateral border of the cerebellum (Fig. 11 χ). The mesial ends of these grooves approaching each other, penetrate into the narrow lobule which is bordered by the sulcus primarius (1) and by the sulcus praepyramidalis (4); afterwards these grooves unite and divide the lobule in an upper and lower half. This differentiation however not always proceeds symmetrically, so that it may happen, that these grooves do not meet, but that one of them unites with the sulcus praepyramidalis; in other cases they grow along of each other, causing in this way an asymmetry of the lobule, which influences the further lobulisation of this region; these cases however are rather exceptional. The appearance of these grooves is known in literature, and it is generally believed that they form the sulcus horizontalis. In the beginning I inclined to the same opinion, but the study of the abundant material which was at my disposition instructed me that this notion is wrong, and that this groove, which appears symmetrically, is the sulcus superior posterior which separates the lobulus lunatus posterior and the lobulus semilunaris superior. The sulcus horizontalis appears afterwards in a manner as illustrated in Fig. 12 and 13.

The fact that the sulcus superior posterior arises in an earlier period of human embryonic life than the sulcus horizontalis seems of interest in connection with other particulars of comparative anatomy. I found namely in my researches on the cerebellum of Primates the sulcus superior posterior appearing phylogenetically before the sulcus horizontalis. All Primates excepted the Arctopithecidae possess a sulcus superior posterior, whereas a sulcus horizontalis is only to be found in Anthropoids, although an indication is also to be found in Ateles. After the formation of the sulcus superior posterior, the lobule between the sulcus primarius and sulcus praepyramidalis quickly increases in size, the cerebellum becoming convex in its median zone. (Fig. 11 and 12. 1, 4 and χ).

In the same period in which the lobulus lunatus posterior - bordered by the sulcus primarius and the sulcus superior posterior — develops its secondary grooves, a short straight groove appears on the upperlip of the sulcus praepyramidalis. This groove is the sulcus horizontalis (Fig. 12 and 13,*h*), which, contrary to the general conception appears in the median portion as an unpaired groove. In the beginning therefore the region between sulcus horizontalis and sulcus praepyramidalis is extremely narrow in its median portion, the region however between the first sulcus and the sulcus superior posterior being relatively large. The first of these regions becomes the Tuber vermis, while the second forms the Folium vermis. If one compares the size of these regions with those of the Tuber and Folium vermis of the adult cerebellum it is evident that there must be a very unequal surface-expansion in these adjacent parts of the cerebellum and that the development of this organ in man is not as simple as it appears. And it may be concluded from the fact that the surface-expansion of the lobules takes place with very different intensity that the signification of the grooves and lobules is not merely a morphological one. The obvious difference in the extension of the cortex of the different lobules ought to have a physiological base.

In the stage of development in which the sulcus horizontalis forms a short straight groove in the forelip of the sulcus praepyramidalis, the Tuber vermis does not yet reach the surface, whereas the folium vermis, which in a later period is concealed, still appears broadly on the surface. This relation is modified by a lamella which mounts to the surface from the bottom of the sulcus praepyramidalis, and which pushing forwards the sulcus horizontalis, separates the latter from the sulcus praepyramidalis (Fig. 12 and 13. *h*, 4). This lamella, arising from the forewall of the sulcus praepyramidalis is the first "Anlage" of the Tuber vermis.

At the same time the sulcus horizontalis has lengthened and penetrates into the hemispheres, soon being equal in length to the sulcus superior posterior (Fig. 15*c*). These sulci include a cuneiform lobule with its top directed mesially, on the surface of which arise secondary furrows, even before the sulcus horizontalis has reached the lateral border of the cerebellum (Fig. 15*a* *b* and *c*). This wedge-shaped lobule is the lobulus semilunaris superior.

The sulcus praepyramidalis has also extended into the hemispheres (cf. Fig. 11 till 15. 4) and with that keeps its typical form for a long time: namely a median horizontal portion of which the lateral parts bend sharply down and back. This typical form enables us to recognize easily this groove. By this course of the sulcus a second cuneiform lobule is formed with its top directed mesially, bordered above by the sulcus horizontalis (*h*) below by the sulcus praepyramidalis (4). This region becomes the lobulus semilunaris inferior. It is remarkable that the first groove which subdivides this lobule also rises from the upperlip of the sulcus praepyramidalis from which again appears that here exists a focus of very intense surface-expansion. This groove penetrating into the lobulus semilunaris inferior can be seen in Fig. 13, 14 and 15 in different phases of development, whereas in Fig. 16*a* a second groove emerges from the underlip of the sulcus horizontalis, quite near the middleline, which grows out into the lobulus semilunaris inferior. By these two intralobular grooves is initiated the subdivision of the lobulus semilunaris inferior into three sublobuli, a fact, to which Ziehen has fixed attention.

The region between the sulcus praepyramidalis (4) and the fissura secunda (2) undergoes but fewer changes and takes part in a slighter degree in the surface-expansion. For a long while this area is broadest in its median zone (Fig. 11, 12, 13 and 14) and shows there one or two short grooves which are however limited to the middle region and do not penetrate into the hemispheres; this broad middle-piece is the Pyramis. The parts of the hemispheres corresponding to the Pyramis are separated relatively late from the rest of the cerebellum. This separating is connected with other phenomena which are of importance for the topographical relation of the cerebellar lobules. The fissura secunda namely, which limites the regions of the Uvula and the Tonsilla on the upper side, extends originally from one lateral border of the cerebellum to the other (Fig. 11—14). The area however, situated above the transversal zone formed by Uvula and Tonsilla, increases more rapidly in transversal direction than the Tonsilla does and in this way the latter is enclosed. By this process the fissura secunda ends no longer at the lateral borders of the cerebellum, but, if observed from behind, at the myelencephalic border (Fig. 15). Now it is mainly that part of the hemispheres which gets situated at the side of the Tonsillae, which by a narrow lamella remains connected with the Pyramis and develops to the lobulus biventer.

The region of the lobulus biventer and Pyramis shows in its lamellisation a characteristic that indicates that the surface-expansions of the middle- and side-pieces are more or less independent of each other. Already I drew attention to the fact that in an early period of development one or two grooves appear in the Pyramis which do not extend into the hemispheres; figures 11—19 show these grooves at a number of two or three. Now we see, that the furrows of the lobulus biventer take their origin quite independently of those of the Pyramis. For according to my preparations the lobulus biventer is lamellised in two ways. From the underlip of the sulcus praepyramidalis arises a groove on some distance from the middleline. This groove lengthening itself in a lateral direction reaches the margin of the cerebellum and divides the lobulus into an upper and under part. In Figures 17, 18 and 19 this groove is indicated by a *b* and is identical with the sulcus bipartiens of Ziehen. The lamellisation of both parts of the lobulus biventer takes place in a different manner. The upper part of this lobule, which is cuneiform in shape develops new grooves, taking their origin from the underlip of the sulcus praepyramidalis or from the upperlip of the sulcus bipartiens, which grooves lengthen laterally; the grooves of the under part, which is a narrow lobule connected with the Pyramis arise from the margin of the cerebellum and grow out mesially. Especially figure 18 shows very clearly this difference in the folding of the cortex of both parts of the lobulus biventer, which difference gets more important when it is compared with the mode of folding in the Uvula and Tonsillae. Like the Pyramis the Uvula too very soon shows one or two transversal grooves, which do not penetrate into the Tonsillae. The surface of the last called lobules remains unfolded for a remarkably long time (Fig. 17 from a foetus of 29 cM. and fig. 18 from one of 32 c.M.) and assumes an oval-shaped rounding. But, the folding of the cortex once commenced, it proceeds in the same way as in the under part of the lobulus biventer. For as can be observed in Fig. 16 and 19, the grooves begin on the margin of the lobules, i.e. laterally and grow out mesially. In connection with this last fact it must be recalled to mind that also the fissure which separates the Flocculus from the remainder of the cerebellum first appears at the lateral edge of the latter and lengthens afterwards in a mesial direction.

The Flocculi and Nodulus have undergone but little differentiation during the described stages of development; the Nodulus has increased in surface and in the number of its grooves; while the Flocculus in an foetus of 35 c.M. (Fig. 19*c*) shows only three lamellae.

A distinct differentiation between the cerebellum and pedunculi pontis is indicated sharply in foetus of 25 to 30 c.M. (Cf. 15*c*, 16*b*, 17*a* and 19*c*). In the foetus of 29 c.M. (Fig. 17*a*) the fossa lateralis is sharply bordered while the sulcus superior posterior (χ) ends in its fore border and the sulcus horizontalis in its top.

In the development of the human cerebellum some interesting phenomena may be observed, which are worth to be brought in the fore-ground and which may be summarised in the following way.

1st. In the grooving of the human cerebellum two stages may be observed; in the first stage those grooves arise that in general are characteristic for the mammalian cerebellum. By these primary grooves the organ is divided into an anterior lobus, which is subdivided into four lobules, and into a posterior lobus, which in the median plane is also subdivided into four lobules. All these grooves take their origin in the middleline. Besides these another groove appears, beginning at the lateral border of the cerebellum (Fissura parafloccularis). In the second stage those grooves become visible, that are typical for the cerebellum of the Primates.

2nd. After the primary grooves in the first stage having been formed the further lobulisation and lamellisation takes place in the second stage in a regular way. In the anterior lobe all the grooves take origin in the middleline and lengthen laterally; the same happens with the maingrooves of the region between sulcus primarius and bipartiens, but in the last region there also arise grooves in the hemispheres which are confined to the latter. Finally between the sulcus bipartiens and the margo myelencephalicus of the cerebellum the grooves begin at the border of the hemispheres and grow out mesially. The system of the grooves belonging to the Pyramis, Uvula and Nodulus forms an independent system, which has no connection with the systems of grooves existing in the adjacent parts of the hemispheres. Consequently from a morphogenetic point of view three zones may be discerned. *Anterior zone*: all grooves arise in the middleline, grow out into the margin of the cerebellum or end at some distance of it. *In this zone the system of grooves is an unpaired one. Middle zone*: the grooves take their origin partly in the middleline and extend to the margin of the cerebellum, partly they arise in the middle of the hemispheres to which they are confined. *This system of grooves is a paired one. Posterior zone:* there arise grooves in the middleline which are confined to a narrow band, while independently of these a second system arises in the hemispheres. *In this zone the system of grooves possesses a threefold character.* The cerebellum of the Primates compared to that of the other Mammals is characterized by a progressive development of the anterior and middle zones and a regression of the posterior zone.

3rd. After the first stage of development having been passed there arise spheres of intense surface-expansion by the side of others, where this expansion is minimal. This is the case with: the most anterior part of the Lobus anterior, which develops into the Lingula; further with the Folium vermis, which at an early period of development reaches the surface as a relatively large lamelle, and the Flocculus, the surface of which enlarges very little. Spheres of intense surface-expansion are: the region in the middle line, immediately surrounding the sulcus primarius; the forelip of the sulcus praepyramidalis, from which arises the whole Tuber valvulae; the region between the sulcus horizontalis and sulcus praepyramidalis. Especially the human cerebellum is distinguished by the mighty development of this part.

The facts brought to notice in 2 and 3 lead to the conclusion that the cortex of the cerebellum is not an organ with a homogeneous distributed function, but a well organised entirety with localised functions.

4th. In general the anterior lobe keeps ahead of the posterior lobe in development, the lamellisation beginning latest in the caudal part of the cerebellum.

5th. In connection with the difference in the mode of lamellisation of the zones described in 2, sulci paramediani are wanting in

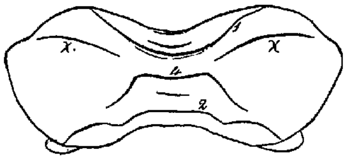
Fig. 11.

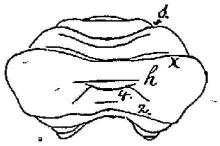
Fig. 12.

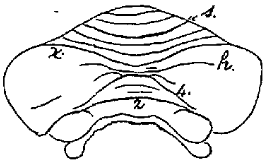
Fig. 13.

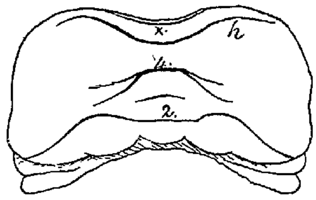
Fig. 14*a*

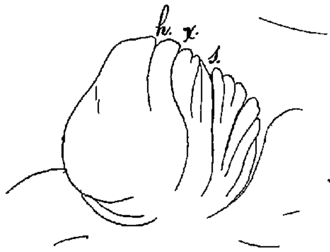
Fig. 14*b*.

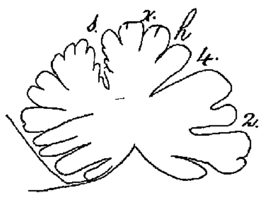
Fig. 14*c*.

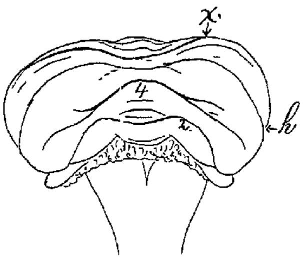
Fig 15*a*.

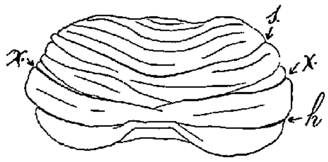
Fig 15*b*.


Fig. 15*c*


Fig. 15*d*

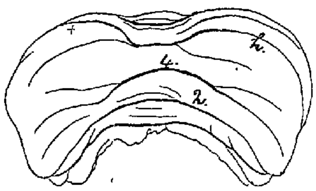
Fig. 16*a*

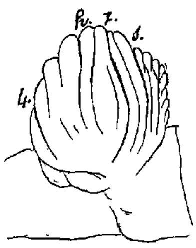
Fig. 16*b*.


Fig. 16*c*.

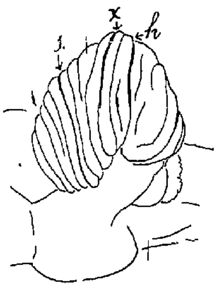
Fig. 17*a*.

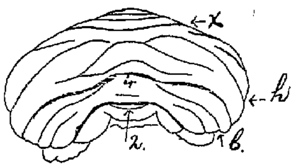
Fig. 17*b*

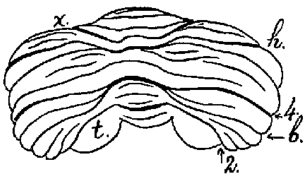
Fig. 18.

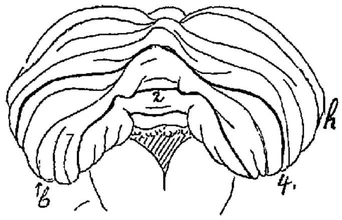
Fig. 19*a*.

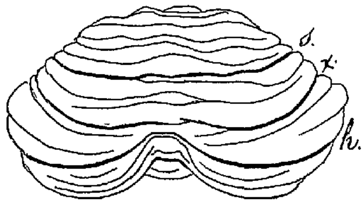
Fig. 19*b*.

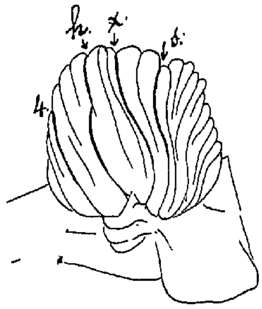
Fig. 19*c*.

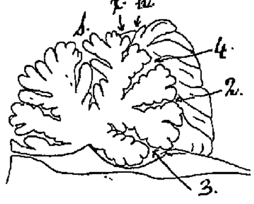
Fig. 19*d*.

the anterior zone, in the middle zone they exist, but continuity between the lamellae of the hemispheres and of the vermis remains, and in the posterior zone they form a complete division between the lamellae of the hemispheres and of the vernis.

Anatomy. — *"On the sympathetic nervous system in Monotremes."* By A. J. P. v. d. Broek. (Communicated by Prof. L. Bolk).

The following description contains the results of an investigation on the structure of the sympathetic nervous system in Monotremes.

For this investigation I had at my disposal a female specimen of Echidna aculeata and of Ornithorhynchus paradoxus. The sympathetic system of the two specimens resemble each other in many respects, i. e. in structure and ramification; in other respects they show important differences from placental mammals.

In the cervical sympathetic chord we find in Echidna one, in Ornithorhynchus two ganglia.

The ganglion cervicale of Echidna is (Fig. 1. g. c.) a rather large, oval-shaped body, situated close above the Arteria subclavia. Singular or double rami viscerales connect this ganglion with the first as far as the fifth cervical nerves included. The ramus visceralis of the first cervical nerve does not enter directly into the ganglion cervicale but is joined to a nerve that appears at the upper end of this ganglion and can be traced as far as the base of the skull (Fig. 1. a.) where it enters into a little foramen. Close to the base of the skull (Fig. 1. b.) two little twigs branch off this nerve, which go through the M. longus colli to the vertebral column. Anastomotical branches of this nerve with the Nervus vagus and the ramus descendens hypoglossi are under the base of the skull. (Fig. 1. c.).

In Ornithorhynchus a little part of the cervical ganglion, which should be considered as the fusion of the ganglion cervicale supremum and medium in placental mammals, is situated on the atlas as a ganglion cervicale supremum (Fig. 2 g. c. s.) and is connected with the first cervical nerve. A thick branch of the Nervus vagus enters into the ganglion from the lateral side; at the medial side the Nervus laryngeus superior (Fig. 2 l. s.) leaves it. In its course this nerve contains a little ganglion before dividing into ramus externus (Fig. 2 r. e. l. s.) and internus.

The rami viscerales parting from the second to the fifth cervical nerves included communicate in Ornithorhynchus with the ganglion