THE LIZARD'S BRAIN

AN INVESTIGATION ON THE HISTOLOGICAL STRUCTURE OF THE BRAIN OF LACERTA VIVIPARA

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MCMXXXI

DE HERSENEN VAN DE HAGEDIS

(LACERTA VIVIPARA)

ACADEMISCH PROEFSCHRIFT

TER VERKRIJGING VAN DEN GRAAD VAN DOCTOR IN DE GENEESKUNDE AAN DE UNIVERSITEIT VAN AMSTERDAM, OP GEZAG VAN DEN RECTOR-MAGNIFICUS Dr. J. D. VAN DER WAALS Jr., HOOGLEERAAR IN DE FACULTEIT DER WIS- EN NATUURKUNDE, IN HET OPENBAAR TE VERDEDIGEN IN DE AULA DER UNIVERSITEIT OP WOENSDAG 13 MEI 1931 DES NAMIDDAGS TE $4^1/_2$ UUR DOOR

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ARTS TE BAARN

DRUKKERIJ C. C. CALLENBACH — NIJKERK

AAN DE NAGEDACHTENIS
MIJNER VROUW

VOORWOORD.

Door den langen tijd, die verloopen is, sedert ik artsexamen deed, zijn al mijn leermeesters reeds overleden. Ik herdenk intusschen velen van hen met groote dankbaarheid.

Zeer veel dank betuig ik U, Hooggeleerden Ariëns Kappers, hooggeachten promotor, voor den grooten steun mij betoond bij de samenstelling van dit geschrift en voor Uw nooit falende bereidwilligheid om mij voor te lichten bij de bestudeering van hersenen, waarvan de bouw mij vroeger geheel en al onbekend was.

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INTRODUCTION.

As there is not yet an Atlas of a series of microscopical sections of the brain of a Reptile, the object of the present work is to afford a survey of the structure of the Lizard's brain, (Lacerta vivipara), which may serve as a guide for further studies, similarly as *Winkler's* and *Potter's* Atlasses of the Rabbit's and Cat's brain.

The first plate shows three drawings made by Mr. *Chr. Vlassopoulos*, scientific artist of the University of Amsterdam, representing the brain as seen from above, from the side, and from below magnified 10 times. Then follow cell preparations, cross sections stained with cressylviolet, and then cross and sagittal sections treated after Weigert-Pal indicating the course of the fibres. In order to make these plates as true to nature as possible, use has been made of microscopic reproduction by means of the large microphotographic camera of Zeiss in the Central Institute for Brain Research, at Amsterdam. The cross sections are not invariably of the same series, but the best of several series have been selected. The sagittal sections, however, are from one and the same series.

To illustrate some peculiarities, I added a photo of a sagittal section treated after Cox, and several drawings of Golgi preparations.

It has not proved feasible to make microphotographs of Golgi preparations, as the various parts of a neuron do not lie on the same level and it is therefore impossible to focus them all at once. For this reason drawings of these preparations have been made with the help of a camera lucida, the greatest care being taken to make these drawings absolutely true to nature.

Before giving my description I want to express my thanks to Prof. Ariëns Kappers director, and to Dr. J. L. Addens, conservator of the Central Institute for Brainresearch at Amsterdam, for their constant help in various respects. I am greatly indebted to the preparators of the Institute, especially to Mr. T. Brouwer for cutting and staining the sections and for his excellent microphotographs.

THE BRAIN OF LACERTA VIVIPARA.

THE CEPHALISATION COEFFICIENT.

Amongst the Reptilia, the relative brain weight varies a good deal. Taking Testudo graeca as an example of the suborder of the Chelones, its appears that its cephalisation coefficient, calculated by *Dubois* [1]) (0,0075) is smaller than that of the Anure Amphibia, (varying from 0,0087, Bufo, to 0,0179, Hyla arborea), smaller even than with the ordinary Salamander (Salamandra maculosa: 0,0078) and only slightly larger than that of Triton (0,0062).

Increasing with the Ophidia (Naja melanoleuca: 0,0098; Vipera berus; 0,0102), it attains its greatest height with the Lacertilia (excepting Anguis fragilis; *Dubois*). —

So with the large Varanus niloticus this coefficient is 0,0165, and with the Gecko 0,0181. —

For two specimens of Lacerta agilis *Dubois* found a mean brain weight of 0,076 gr. with a bodyweight of 12,507 gr., giving a coefficient (K—), of 0,0185; and for Lacerta viridis the same author found an average brain weight of 0,093 with an average body weight of 16,8 gr. which calculated according to his formula even gives a cephalisation coefficient of 0,0191.

With the help of Mr. Addens I calculated the cephalisation coefficient of Lacerta vivipara according to *Dubois'* formula $K = \frac{E}{P^{0.56}}$ (the figures expressed in grams) The average weight of the bodies (including the brain) of three adult male specimens was 3,46 gr. The average brain weight of these specimens being 0,024 gr., the cephalisation coefficient is 0,0121.

[1]) *Dubois*. De betrekking tusschen hersenmassa en lichaamsgrootte bij de gewervelde dieren. Verslag van de Wis- en Natuurk. Afd. der Kon. Akad. v. Wetensch. te Amsterdam.

From this appears that its cephalisation coefficient is lower than that of the other Lacertilia hitherto examined, and that although in the order of the Reptiles the Lacertilia have the greatest cephalisation coefficient, it remains far under that of birds (varying from 0,06 in the Pheasant to 0,30 in the Parrot [1]).

[1]) *Lapicque* et *Girard* Poids de l'encéphale en fonction du poids du corps. Compte rendu de l'Acad. des sciences, T. 140, 1905.

GENERAL MORPHOLOGY OF THE CENTRAL NERVOUS SYSTEM.

The general morphology of the brain appears from the drawings on the first Plate, to which I have little to add.

The pearshaped *hemispheres* end frontally in the slender elongated anterior olfactory lobes, the formatio bulbaris lying on a considerably more frontal level, very near the olfactory epithelium, so that the fila olfactoria are not very long.

The *parietal eye* and *epiphysis* are not drawn as they have been removed in preparing the brain. They have been carefully described by *Spencer*, *Owsjannikow*, *Strahl-Martin*, *Leydig* and *Studnicka* [1]) as a flattened vesicle lying in the foramen parietale of the skull. The flattening causes the lens epithelium to lie closely against the retina. Nerve fibres from the latter are traced into the thalamus (parietal nerve). The epiphysis, the connective tissue capsule of which continues into the capsule of the parietal eye is fairly large (cf. fig. 18) and still contains some pigment.

The *hypophysis*, very distinct in Plate I, is relatively large, specially its main lobe (the anterior lobe of human anatomy) extending far backwards. The intermediate lobe separated from the former by a distinct cleft, still shows a tubular arrangement of its epithelium, and covers the anterior and caudal part of the hollow infundibular stalk *(Stendell)*.[2])

Superficially seen the *midbrain* consists of two colliculi only, the corpora quadrigemina anteriora or tectum opticum. The colliculi posteriores however are not failing and even protrude partly behind the corpora anteriora, but being covered by the exverted cerebellum, this protrusion is not visible in the drawing. Besides the larger part of the colliculi posteriores as

[1]) *Studnicka.* Die Hypophysis cerebri. Oppel's Lehrbuch der vergleichende Mikrosk. Anatomie, Bnd. 5, 1905.

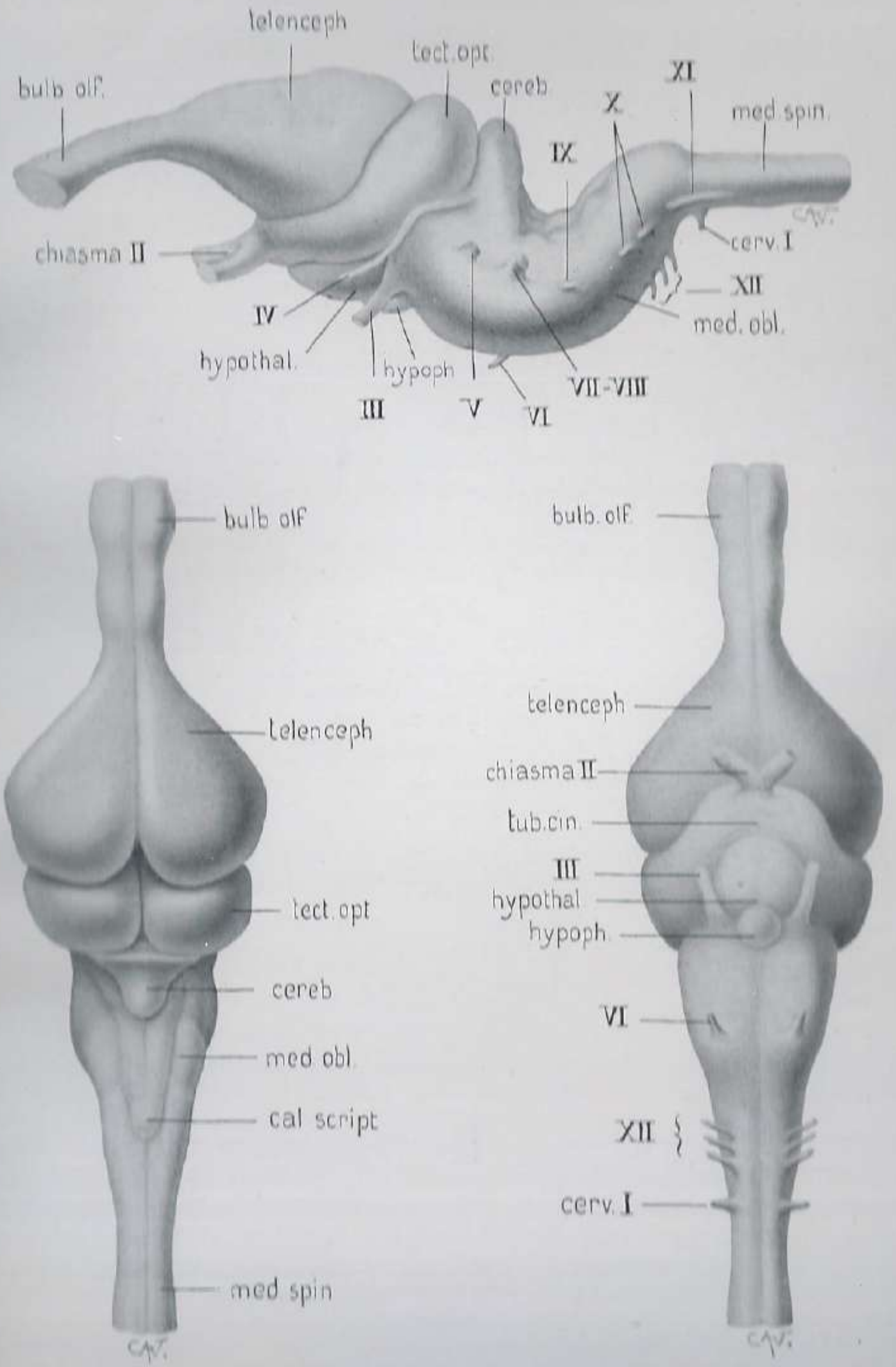
[2]) *Stendell.* Die Hypophysis cerebri. Oppel's Lehrbuch der vergleichenden Mikroskopischen Anatomie, Bnd. 8, 1914.

it is with Fishes and Amphibia lies underneath the tecta optica in the form of tori semicirculares. Immedially behind the midbrain, at the dorsal side of the isthmus slight bilateral protrusions occur, the ganglia isthmi. They are however not nearly as conspicuous as e. g. with the Chamaeleon *(Kappers)* and even less protruding than in Varanus.

At the bottom of the midbrain peduncle, the feet (pedes pedunculi), such typical features of the mammalian peduncles are failing, a fact to be correlated with the absence of pontine and pyramidal tracts.

The relatively small *cerebellum* belongs to the exverted type, i. e. its granular layer is turned inside out, bulging backward. Its molecular layer lies against the tectum, covering the corpora quadrigemina posteriora. Small bilateral protrusions at the ventro-caudal edge of the cerebellum near the upper surface of the oblongata may represent a rudimentary floccular formation, much less developed though than in crocodiles. The caudally bulging granular layer of the cerebellum covers nearly the whole rhomboid ventricle inside the plexus choroideus that attaches at the upper edge of the cerebellum. At the bottom of the oblongata a pontine formation fails (vide supra). All nerve roots are distinct, microscopically even some small scattered rootlets of the abducens. The latter however could not be seen macroscopically and consequently are not indicated in my drawing, where only its main root is represented (see however Plate 51 of my atlas).

The *spinal cord* is very regular in its form, the cervical and lumbo-sacral enlargements not being very conspicuous. Caudally its size gradually diminishes extending into the coccygeal region of the vertebral column. The great incongruency of length between the spinal cord and vertebral column, so common with mammals, especially with man, does not exist in these animals that have kept a metameric tail musculature.



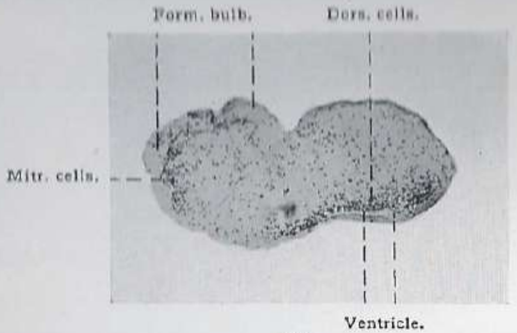


Fig. 1.

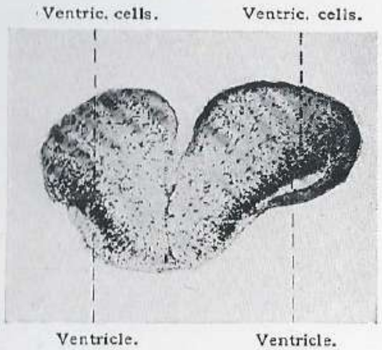


Fig. 2.

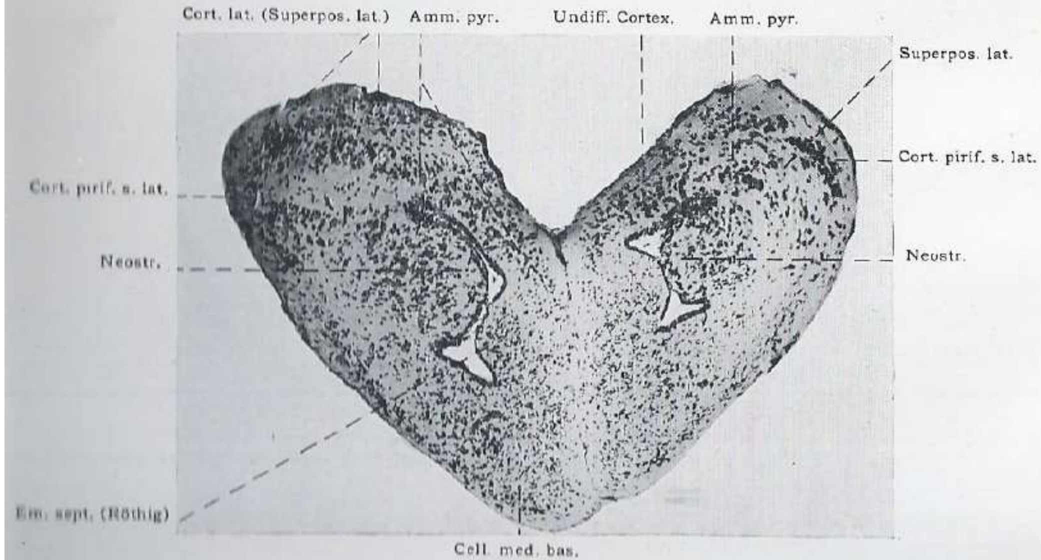


Fig. 3.

MICROSCOPICAL ANATOMY OF THE CENTRAL NERVOUS SYSTEM.

THE CELL GROUPS: CRESSYL SERIES OF TRANSVERSE SECTIONS.

FOREBRAIN.

Fig. 1. This section has cut the bulbus olfactorius obliquely so that the left side does not yet show a ventricle, but, latero-dorsally a group of mitral cells is found under the formatio bulbaris (bundles of fila olfactiva). On the right the ventricle is quite conspicuous ventrally as a very narrow slit, the cells being confined mainly, to a region dorsal from the ventricle.

Fig. 2. Behind the former. Also in this section the ventricle is not yet to be seen on the left, but the cell group has shifted ventrally in such a way that it already indicates where the ventricle will make its appearance further caudally. On the right the ventricle extends chiefly in a direction from latero-dorsal to ventro-medial. The cell-grouping here is as in fig. 1, except that the number of cells has considerably increased.

Fig. 3. Behind the above. Cross section of the frontal portion of the forebrain, in which the lateral ventricle is still a narrow fissure. The latero-dorsal cluster of cells, seen in this figure is the beginning of the cortex piriformis. Laterally protruding into the ventricle a dark-stained group of cells is visible for the first time, consisting of smaller groups mostly lying close together: the neostriatum. Further, a large group of cells in the ventral portion of the hemisphere, and continuing ventrally in the ventro-medial cells.

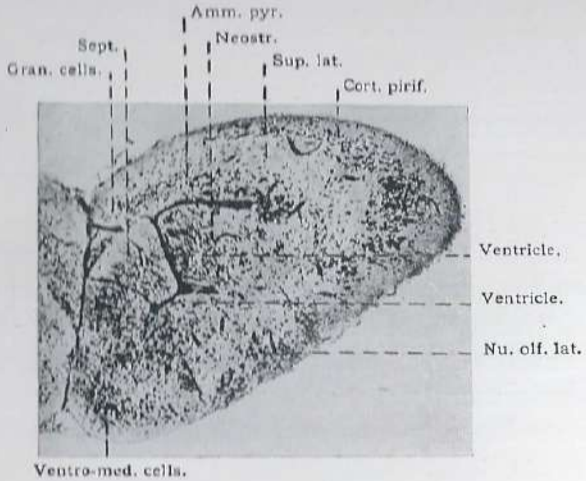


Fig. 4.

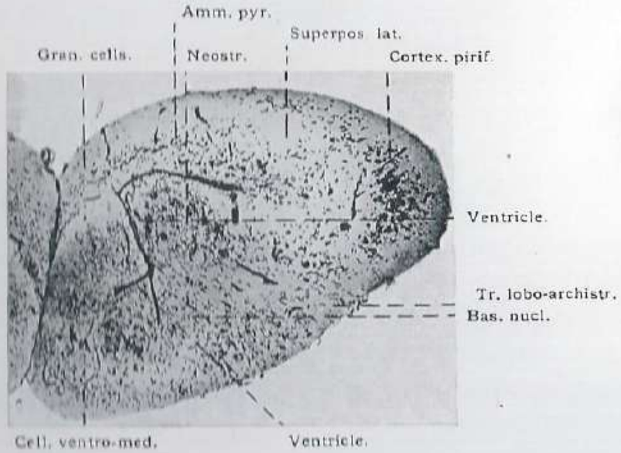


Fig. 5.

Fig. 4. Behind the above. In cross section the ventricle has the form of an S, which, posteriorly only, changes slightly owing to the length of the upper horizontal split becoming somewhat greater. In this section the septum is clearly defined. Its dorso-medial border is formed by a cellfree zone. Dorso-medially of this zone a few granules appear of what will later be the fascia dentata. Dorso-laterally we observe a layer of pyramidal cells, separated (superposito lateralis) from the cortex piriformis which grows over it, but which, more caudally, grows inward in the direction of the neostriatum. On top of the large ventro-medial cells the septum divides into a dorsal and a ventral portion. Laterally at the bottom the nucleus olfactorius lateralis is seen adjacent to the ventral continuation of the cortex piriformis.

Fig. 5. Behind the above. The ventriculus lateralis has grown somewhat larger in the manner above described. In the mantle the layer of granular cells (fascia dentata) has become very distinct. Between the septum and the fascia dentata a zone poor in cells is seen. The cells of the neostriatum are specially crowded on the boundary of the ventricle, but there is an indication of a connection between the lateral cortex and the neostriatum (cf. also Crosby,[1]) fig. 6). Between this connection and the nucleus olfact. lateralis a group of fibres is seen, the tractus lobo-archistriaticus. Medially to the nucl. olfactorius lateralis (not designated here, see above) lies the beginning of the basal nucleus of the striatum.

[1]) *Crosby*. The forebrain of Alligator Mississippiensis. Journ. of Comp. Neur., Vol. 27, 1917.

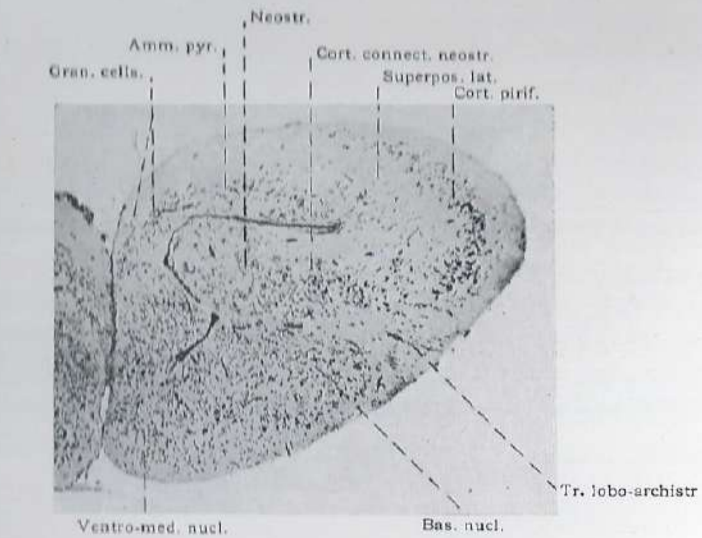


Fig. 6.

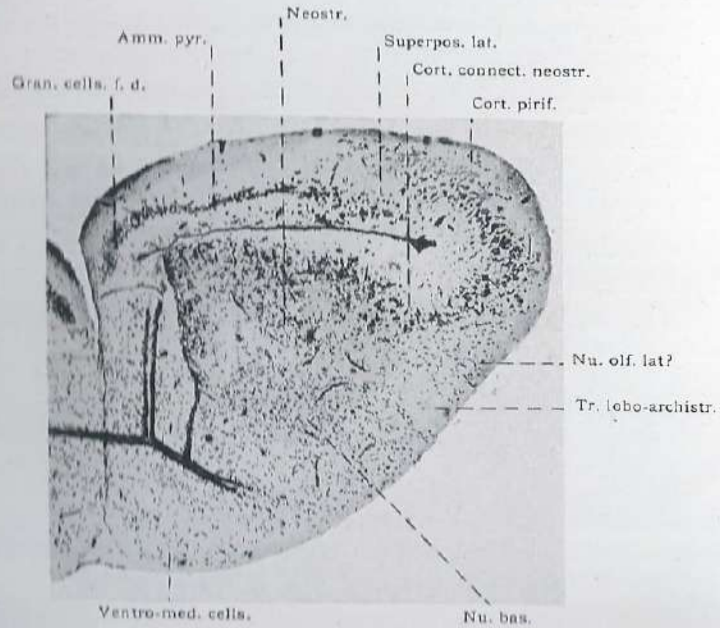


Fig. 7.

Fig. 6. Behind the above. The aspect of the section has changed only in respect to the lateral ventricle which has grown much larger, and to the cells of the neostriatum, which for the greater part are lying on a greater distance from the wall of the ventricle, while the connection between the neostriatum and the cortex piriformis has become much more distinct.

Fig. 7. Behind the above. The granular cells of the fascia dentata now lie in a broad layer forming a section of a circle, and passing, without any clearly defined boundary line, into a rather narrow strip of pyramidal cells, apparently the Ammon pyramids. The pyramidal cells are covered laterally by a broad, well-developed cortex piriformis (superpositio lateralis). The basal nucleus (paleostriatum) has grown much larger, and lies adjacent to the tractus lobo-archistriaticus, oval in form. Dorsally of this tract a rest of the nucleus olfactorius lateralis of *Crosby*.

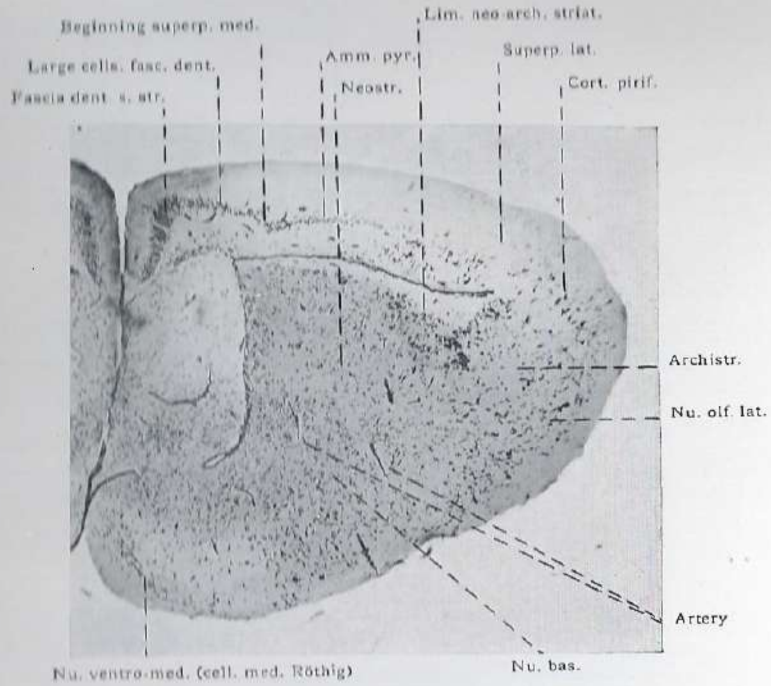


Fig. 8.

Fig. 8. Behind the above. The dorso-medial cortex is more sharply distinct from the septum: the latter having considerably increased in size. The granular layer of the fascia dentata is detached from the well-developed layer of Ammon pyramids. Between them the beginning of the superpositio medialis is seen. The neostriatum occupies the greater part of the striatum. Ventrally a row of bloodvessels (striatal arteries) corresponds with the position of the paleostriatum (nucl. basalis and its surrounding cells). Laterally we see for the first time the archistriatum (secundary epistriatum) lying laterally to the neostriatum. Ventrally of the archistriatum perhaps a caudal extension of the nucl. olfactorius lateralis. Ventrally of the striatal arteries the paleostriatum is seen consisting of fairly large cells, the basal nucleus, covered by smaller ones.

The ventro-medial nucleus (*Röthig*) is much like that in Fig. 7. It continues laterally forming the diagonal band of Broca (cf. *Crosby*) [1]).

[1]) *Crosby*. The forebrain of Alligator Mississippiensis. Journ. of Comp. Neurology, Vol. 27, 1917, fig. 8 and 9. —

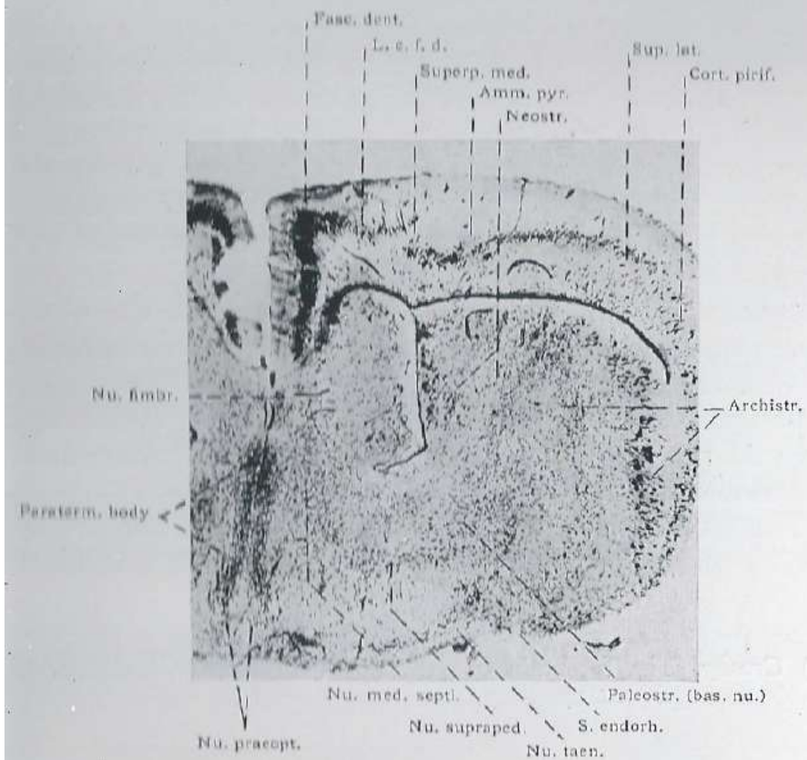


Fig. 9.

Fig. 9. Behind the above. The ventriculus lateralis now surrounds the neostriatum also on the lateral side. The profusion of blood-vessels in the entire neostriatum, as compared to the archistriatum, is very distinct. Ventrally the nucleus taeniae is seen near the sulc. endorhinalis, which sulcus is still more pronounced, but not labelled in the next section (fig. 10). — On the nucl. taeniae lies the peduncle as a white spot covered by a nucl. suprapeduncularis extending from the paleostriatum into the septum. Between the latter and the neo-and archistriatum the paleostriatum (basal nucleus) occurs. The fissure between the two hemispheres is no more continuous, the septa of both sides growing together in the paraterminal body (*E. Smith*).[1]) In the septum, dorsolaterally the lateral septum nucleus is evident. Mesially we see the nucleus medialis septi of which the nucleus fimbriae is the most dorsal part. Ventrally round the compressed praeoptic ventricle (invisible in the photo) lies the nucleus praeopticus, the lower end of which turns laterally.

In the cortex the separation between the fascia dentata and ammon pyramids (superpositio medialis) has become complete. The dorsolateral cells of the fascia dentata, are considerably larger than its other cells. —

[1]) Since the ventral part of the fissure between the right and left hemispheres of the forebrain is absent for the first time in section 113, and the third ventricle makes its appearance in section 124, of the same series the thickness of the corpus paraterminalis must be $11 \times 5 = 55$ micra (in a Weigert-Pal series in which the sections had a thickness of 10 micra, this region had a thickness of 5 sections; i. e. $5 \times 10 = 50$ micra, (thus nearly the same).

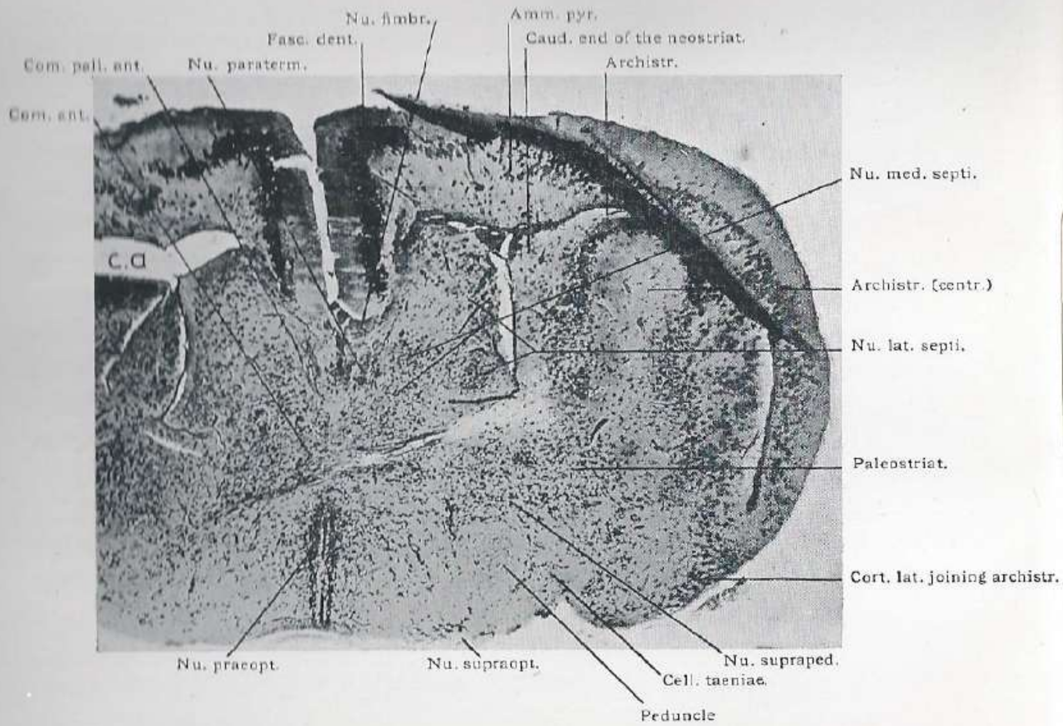


Fig. 10.

Fig. 10. Behind the above. In the septum the medial nucleus has become smaller and the nucleus lateralis septi has increased along the ventricle. In the most ventral portion of this nucleus the cells lie closer together. In this section two commissures are to be seen: the commissura anterior and, more dorsally, the commissura pallii anterior. In the commissural bed and in the space enclosed between the lateral extensions of the commissure, a small nucleus occurs to which I propose to give the name of nucleus paraterminalis; its well impregnated cells are clearly defined from the nucleus medialis septi. More dorsally in the fimbria, lies the nucleus fimbriae. The caudal end of the neostriatum is seen medially in the striatal complex. In Lacerta it ends a considerable distance before the foramen Monroï, in one series 70 micra in front of it. The archistriatum has considerably increased, showing a central part poor in cells and a highly celluliferous border. This border joins the lateral cortex. Ventrally the paleostriatum joining the nucleus suprapeduncularis. Ventrally in the median line we find a fissure-like extension of the ventriculus praeopticus, surrounded by the praeoptic nucleus. Quite ventrally lies the nucleus supraopticus, above the nervus opticus, a portion of which can be seen at the lower edge of the section. Only a few cells of the nucleus taeniae are left.

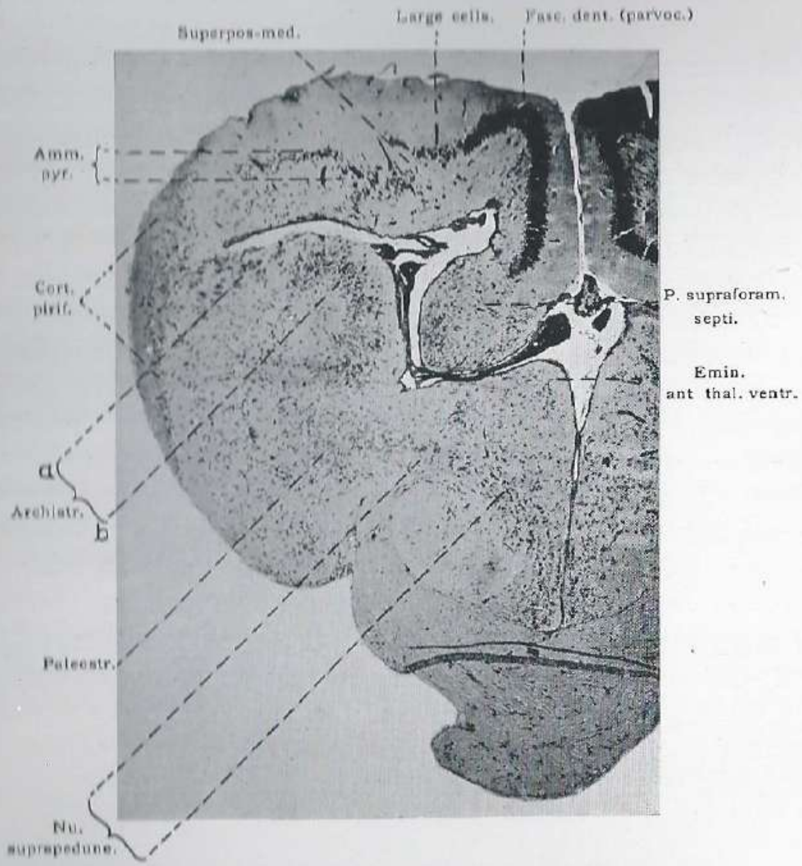


Fig. 11.

Fig. 11. Behind the above. This section goes through the foramen Monroï. Before the foramen Monroï the medial wall of each hemisphere consists of three parts: the dorsal portion containing the fascia dentata, a middle portion, or septum and, lastly the ventro-medial wall. The latter continues into the ventral thalamic eminence. The ventral part of the septum disappears and under its continuation in the lateral choroid plexuses the lateral ventricles of the forebrain open into the frontal extension of the third ventricle: the ventriculus medius telencephali. A part of the upper portion of the septum remains: the pars supraforaminis, or pars fimbrialis septi.

In the forebrainmantle the overlapping of the piriform cortex and Ammonpyramids, the lateral superposition, has become indistinct. The cortex piriformis has extended ventrally. Owing to the absence of the neostriatum the archistriatum now borders immediately on the lateral ventricle. It consists of two cellgroups the lateral of which in continuous with the pallium. It is separated by a non-celluliferous strip from the paleostriatum, which is continuous with the nucleus suprapeduncularis.

Immediately below the foramen Monroï (in the eminentia anterior thalami ventralis of *Herrick)* no distinct cell-group can be distinguished; the cells being widely scattered. Ventrally the tractus opticus encloses the brain.

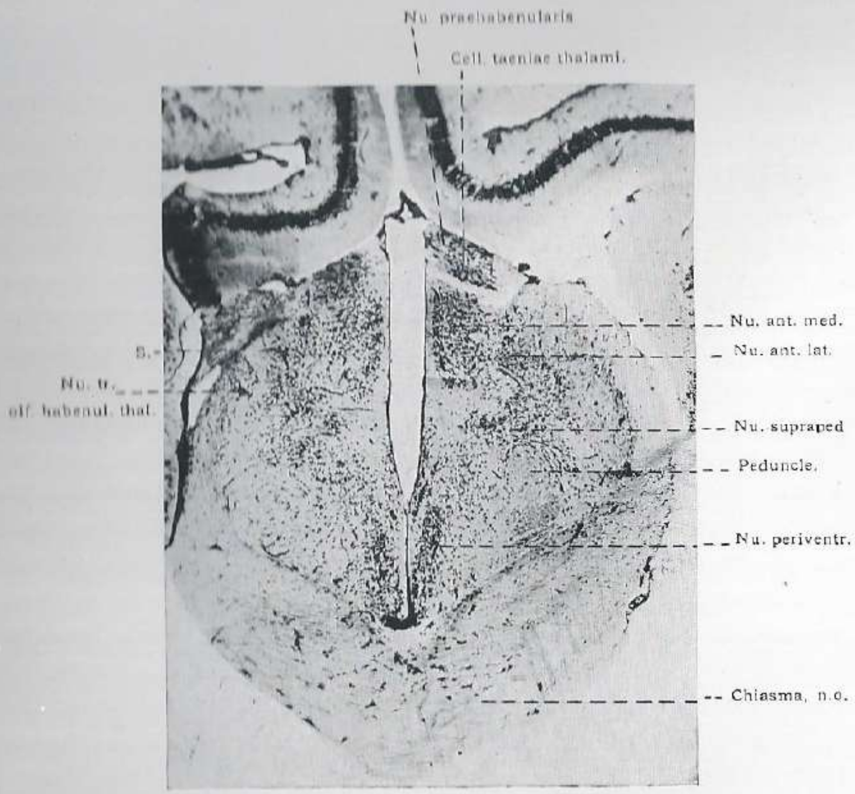


Fig. 12.

TWEENBRAIN.

Fig. 12. Behind the above. Cross-section through the anterior portion of the 'tween-brain. At the left side the attachment of the pars supraforaminialis (or fimbrialis) septi (S) to the thalamus. Through this the tractus cortico-habenularis passes from the forebrain into the taenia thalami (cf. the Weigert-Pal series, Fig. No. 40). Immediately under this attachment some cells: the nucleus tractus olfacto-habenularis thalami, lie along the tractus olfacto-habenularis, in direct juxtaposition to the tr. opticus. The nuclei of the 'tween-brain at the right side are: dorsally, the frontal portion of the ganglion habenulae (nucleus praehabenularis), separated very distinctly by a white cell free zone from the regio subhabenularis. In the latter lies the nucleus anterior medialis thalami, and laterally from this a second group of cells: the nucleus anterior lateralis, which is not distinctly separated from the nucleus suprapeduncularis. The latter contains larger cells than the nucleus anterior lateralis and spreads like a cap over the peduncle. Ventrally, next to the narrow portion of the ventricle, a very distinct group forms, *Edingers* nucleus periventricularis, a caudal continuation of the nucleus praeopticus, passing (see the left side) dorsolaterally into a nucleus suprapeduncularis.

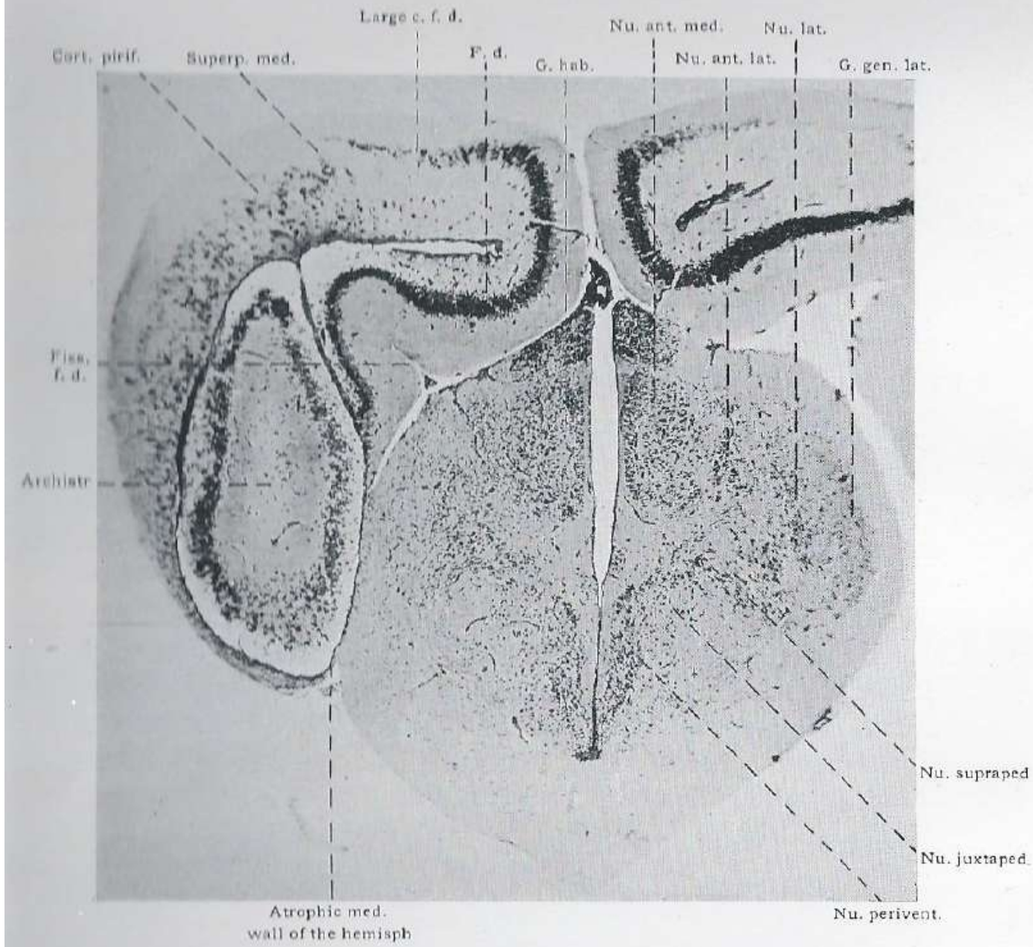


Fig. 13

Fig. 13. Behind the above. The connection of the thalamus with the forebrain has disappeared.

The wall of the hemisphere lying against the thalamus is a thin lamella (atrophic pallium). Dorsally this lamella passes into the fascia dentata, which is folded, thus forming a fissure the f. fasciae dentatae (not to be confused with the mammalian fiss. hippocampi). —

At the right side the ganglion habenulae has grown larger, Similarly the nucl. anterior medialis below it: nucl. dorsomedialis anterior, *Huber* and *Crosby* [1]). Those cells of the latter, that lie near the ependyma are more closely arranged. The nucleus anterior lateralis (nucl. dorsolateralis anterior, *Huber* and *Crosby)* [2]) is reduced in size and more separated from the nucleus suprapeduncularis. Laterally from the nucl. anterior lateralis a new group of cells has appeared, to be named provisionally nucleus lateralis. It extends further ventrally than the nucleus anterior lateralis. Laterally from this nucleus a number of scattered cells lie in the concavity of the tractus opticus similarly as described by *Huber* and *Crosby* [3]), in the Alligator (l. c. fig. 7). They are the cells of the ganglion geniculatum laterale. The nucl. suprapeduncularis has joined the nucleus juxtapeduncularis that passes over into the nucleus periventricularis hypothalami.

[1]) *Huber* and *Crosby* Thalamic and tectal nuclei and fibres in the brain of the American Alligator, Journal of Comparative Neurology, Vol. 40. No. 1, Febr. 1926 p. 112. —

[2]) l. c. p. 122.

[3]) l. c. p, 120. —

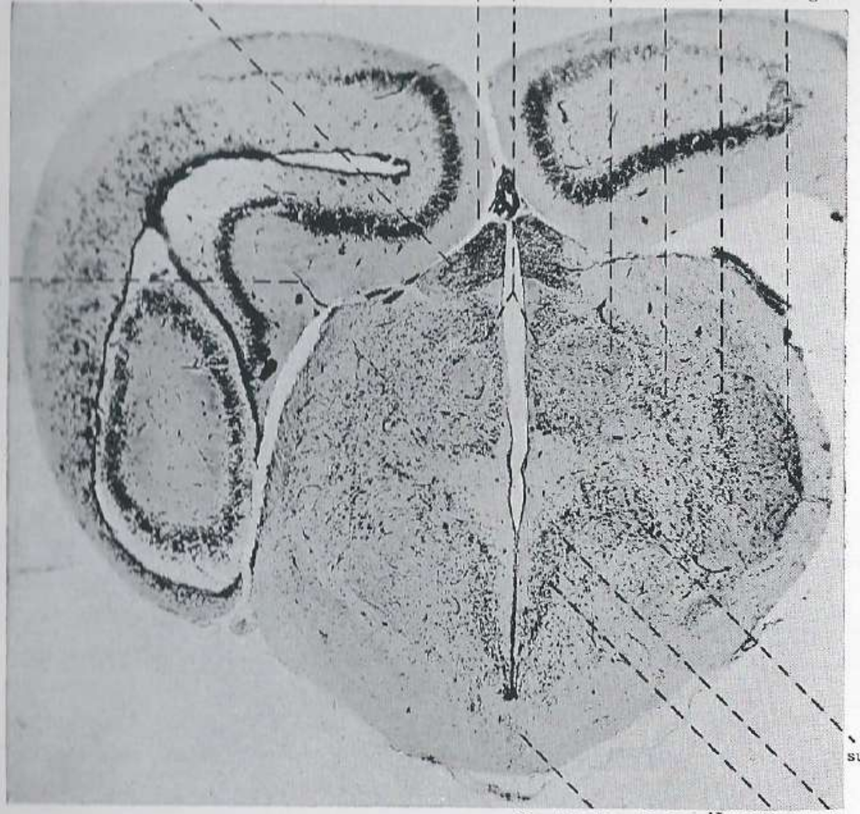


Fig. 14.

Fig. 14. Behind the above. The ganglion habenulae has grown still larger and in it, more especially at the left, we may distinguish a lateral, less compact, and a medial, more compact group. The lateral group containing small and large cells lies within the taenia thalami proper (cf. also *Huber* and *Crosby*). [1])

In the region of the nucleus anterior a round group of cells has developed centrally: the nucleus rotundus, separated by a lighter coloured ring from the surrounding cells of the nucleus anterior which thus is divided into a nucleus anterior medialis and a nucleus anterior lateralis. *Huber* and *Crosby* seem to consider the thus divided cell groups as belonging to their medial nucleus (l. c. 126). These cells enclose the rotundus like a cap, extending especially medio-ventrally (nucl. medialis posterior thalami *Huber* and *Crosby*), the nucleus anterior lateralis being soon reduced in size, (see especially at the right of the figure).

The nucleus lateralis proper has grown larger. Along the tractus opticus lie the scattered cells of the ganglion geniculatum laterale. The nucleus suprapeduncularis passes over through the nucleus juxtapeduncularis into the nucleus periventricularis hypothalami; ventrally from the latter, a few cells of the tuber cinereum are seen.

[1]) l. c. p. 105. —

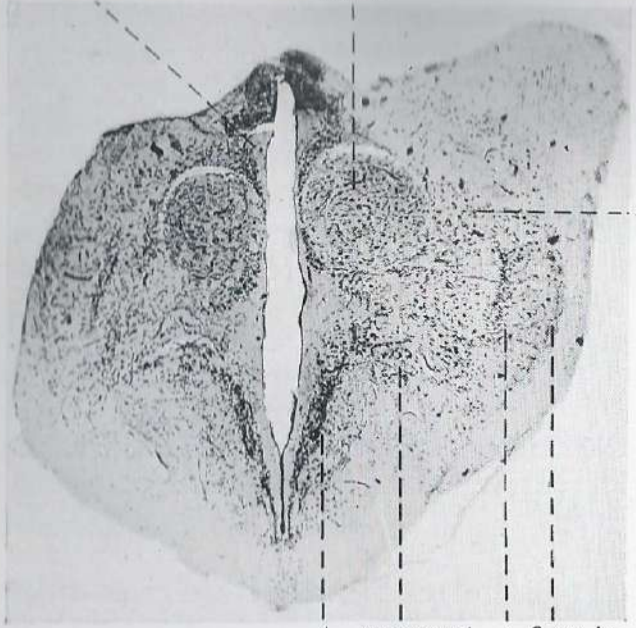


Fig. 15.

Fig. 15. Behind the above. The nucleus anterior medialis is smaller than before, the nucleus rotundus much larger. At the place of the nucleus anterior lateralis another more diffuse group of cells appears, which further backward passes into the nucleus lentiformis (cf. fig. 16). Beneath this group lies the thin, but high nucleus lateralis. Laterally from the latter some scattered cells of the ganglion geniculatum laterale. The nucleus suprapeduncularis still joins the nucleus juxtapedun-cularis. The lateral group of these cells has become more indepen-dent; the medial group is still connected with the periventricular nucleus which has broadened laterally by some scattered clusters of cells.

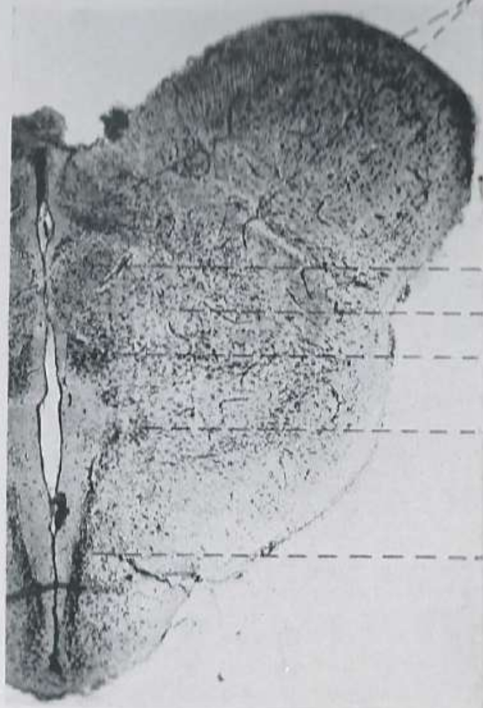


Fig. 16.

Fig. 16. Behind the above. The nucleus lateralis has totally disappeared. Dorso-laterally from the nucleus rotundus the nucleus lentiformis is now very large. The nucleus rotundus it-self has extended laterally. Medially, under the latter and lying against it, a nucleus appears which I shall provisionally call nucleus thalami ventralis. The nucleus periventricularis is still visible, but a separate nucleus tuberis cinerei is no more visible. Between the nucleus periventricularis and the nucleus ventralis a new group of scattered cells, the nucleus tegmenti medialis anterior, begins to develop (cf. also fig. 17 and 18).

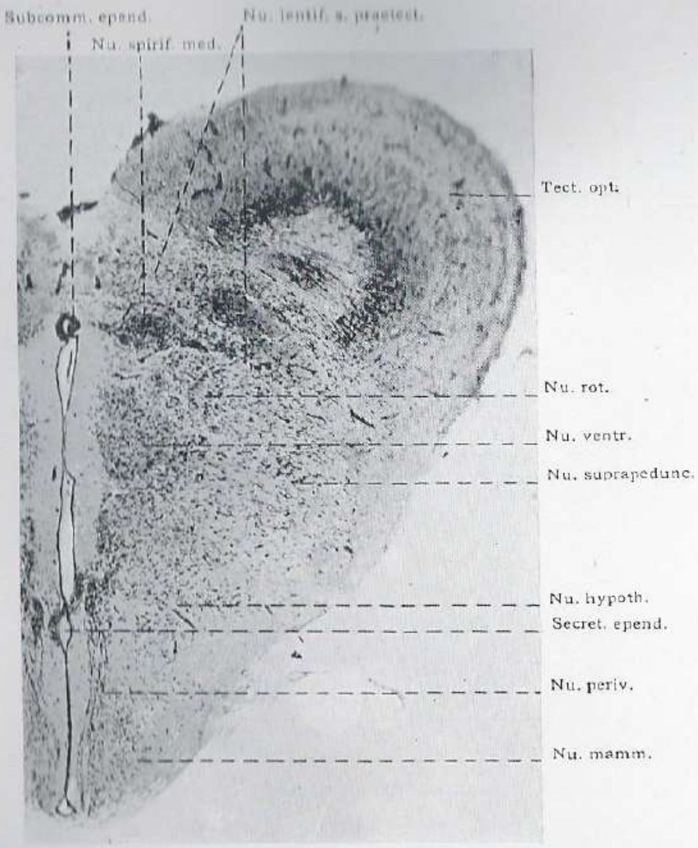


Fig. 17.

Fig. 17. Behind the above. A large portion of the nucleus lentiformis (s. praetectalis) is still to be seen, and medially, below it, a group of cells which may be named nucleus spiriformis medialis. Under these cell groups lies the posterior continuation of the nucleus rotundus, extending more laterally; Ventrally and medially from the nucleus rotundus lies the triangular, darkly impregnated nucleus, provisionally called nucleus ventralis in the preceding section. Of the nucleus suprapeduncularis the lateral, more independent, group is still left; the medial portion, united with the nucleus periventricularis, has partly disappeared and partly merges into the nucleus ventralis. The nucleus periventricularis exhibits a lateral outgrowth into the hypothalamus: the nucleus hypothalami, and another into the regio mammillaris: the nucleus mammillaris. Dorsally the non-secreting, subcommissural thickening of the ependyma of the third ventricle is evident. Similarly the more ventral secreting ependyma (*Kappers* [1]), *Charlton* [2])) on the boundary between the thalamus and the hypothalamus.

---

[1]) *Kappers.* Vergleichende Anatomie des Nervensystems der Wirbeltiere und des Menschen. Teil II, Bohn, Haarlem, 1921

[2]) *Charlton.* A Glandlike ependymal structure in the brain. Proceed. Kon. Akad. v. Wet. Amsterdam, Vol. 31, 1928.

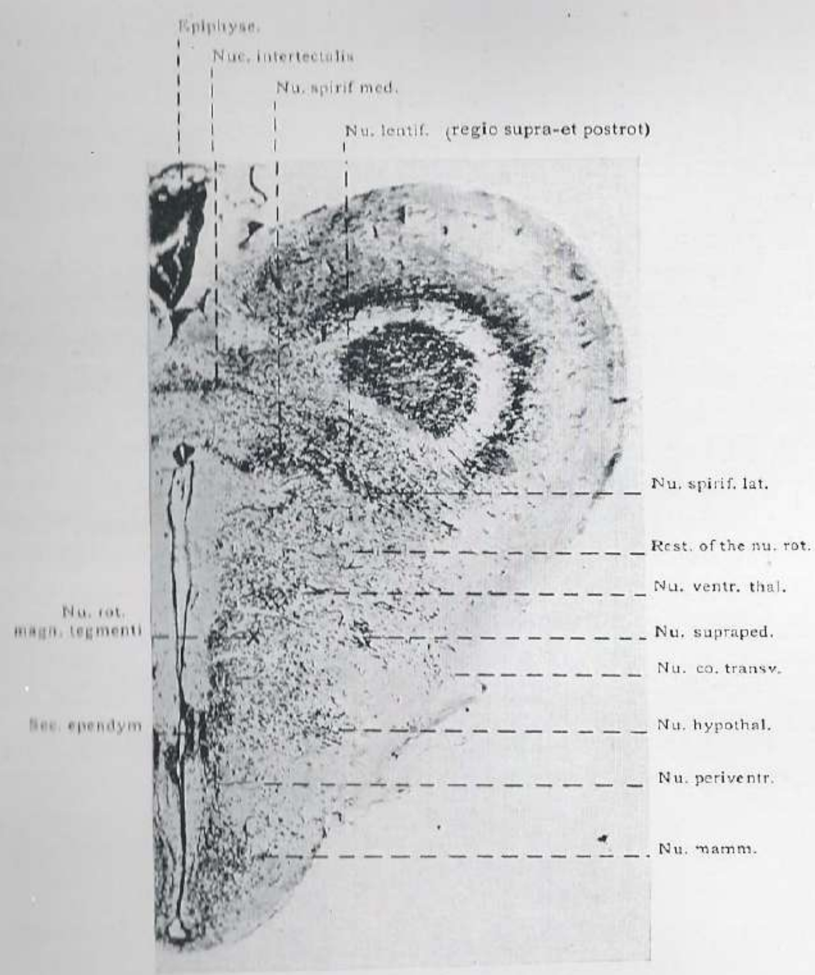


Fig. 18.

Fig. 18. Behind the above. Dorsally we find the glandular tissue of the epiphysis pushed sligtly backward. Underneath it, in the median line of the tectum we find a transverse group of cells, accompanying the commissura posterior (nucleus intertectalis). Laterally the posterior end of the nucleus lentiformis (or praetectalis) is seen. Under the latter nucleus and slightly more medially lie the nucl. spiriformis lateralis and the nucl. spiriformis medialis, adjacent to the commissura posterior. Below the nucleus spiriformis lateralis the rest of the nucl. rotundus appears. Ventromedially the reduced ncl. ventralis. More ventrally, near X, the nucl. reticularis magnus tegmenti, which enlarges still very much in its caudal extension.

Laterally we see a horizontal cell group, probably a nucleus of the comm. transversae. [1])

---

[1]) If this be right this nucleus would correspond to the nucleus transversus infrageniculatus, described by *Prececbtel* in the elephant, being a nucleus of Gudden's commissura transversa Prececbtel's nucleus is probably the same as the nucl. C of the geniculatum mediale, described in the cat. by *Winkler* and *Potter*. See: *Prececbtel.* Some notes on the finer anatomy of the brain, stem and basal ganglia of Elephas indicus Proceed. Kon. Akad. v. Wetensch. Vol. 28, 1925.

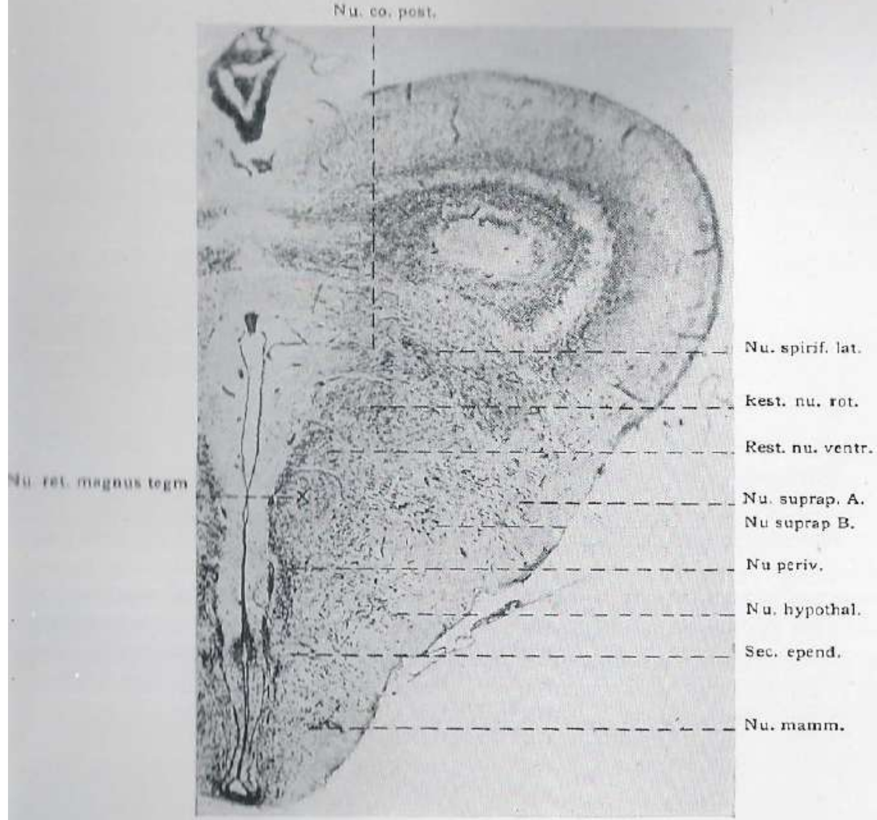


Fig. 19.

Fig. 19. Behind the above. The nucleus intertectalis has divided into two, lying above each other. The lower intertectal nucleus apparently belongs to the lower, the upper to the upper stratum profundum tecti. Only the lateral portion of the nucl. spiriformis is still visible. This, as in birds, thus extends farthest backward. The caudal extensions of the nucleus rotundus and ventralis are considerably reduced. The large cells of the nucl. suprapeduncularis are still visible. Near X lies the nucleus reticularis magnus tegmenti now enlarged.

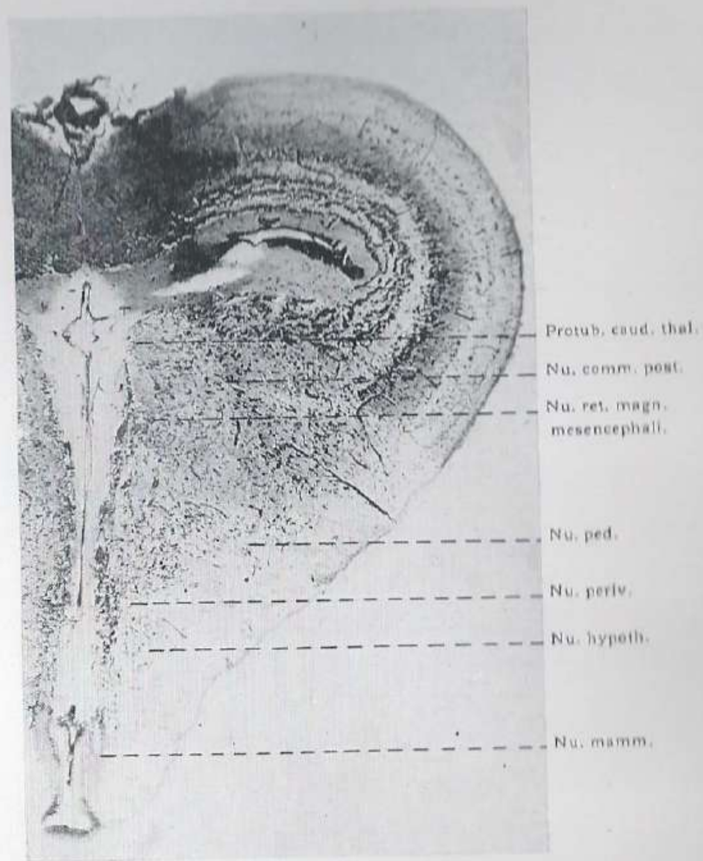


Fig. 20.

Fig. 20. Behind the above. The rests of the nucleus rotundus and ventralis form what might be called the protuberantia caudalis thalami. Latero-ventrally from this the nucleus commissurae posterioris is seen, ventrally the nucl. reticularis magnus mesencephali (X in the preceding figure). The rest as in fig. 19.

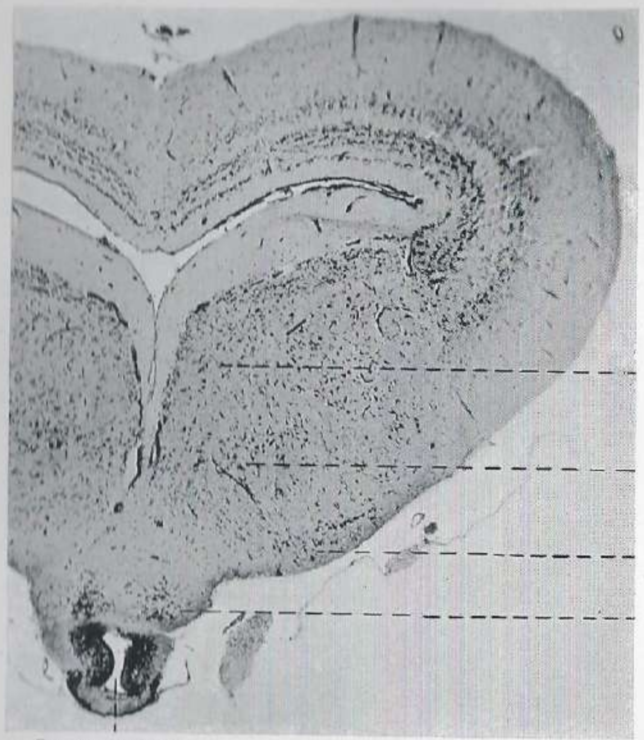


Fig. 21.

MIDBRAIN.

Fig. 21. Behind the above. The protuberantia caudalis thalami with the rests of the nucleus rotundus (and ventralis) has disappeared. The nucleus reticularis magnus now forms the uppermost [1]) part of the tegmentum mesencephali. The nucleus commissurae posterioris, lying between the fibre bundles of the commissura posterior, joins the dorsal part of the nucleus reticularis magnus mesencephali. Together they may be called nucleus reticularis dorsalis, in contra distinction to a nucleus reticularis ventralis.[2]) At the ventro-lateral periphery the nucleus basalis nervi optici (*Edinger*, *Huber* and *Crosby*, nucl. opticus tegmenti *Kuhlenbeck* [3]). At the bottom the nuclei corp. mammillaria and underneath it the rec. mammillaris sive rec. hypothalami posterior.

[1]) The nucleus retic. magnus (dorsalis), together with the nucl. spirif. med., seems to correspond to the nucl. mesenc. dors. described in Teleosts by *Craigie* and *Brickner*. Cf. Structural parallelism in the midbrain and tweenbrain of Teleosts and Birds. Proceed. Kon. Akad. v. Wet. Amsterdam, Vol. 30, 1927.

[2]) This nucleus retic. ventralis may be homologous with the nucl. mesencephali ventralis of Brickner.

[3]) *H. Kuhlenbeck*. Vorlesungen über das Zentralnervensystem der Wirbeltiere, Fischer, Jena, 1927, fig. 148, p. 207.

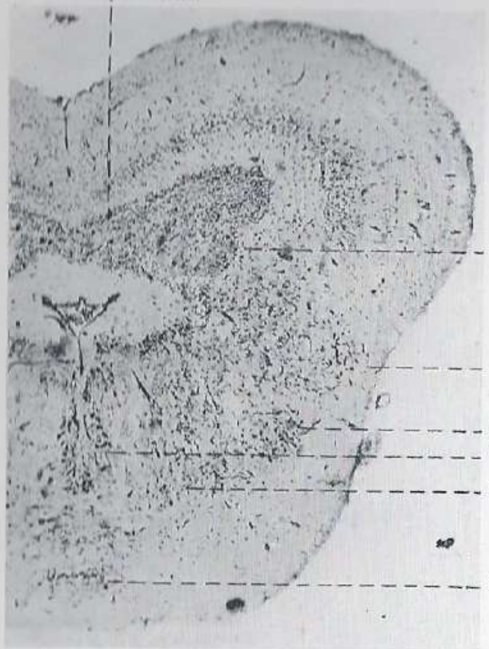


Fig. 22.

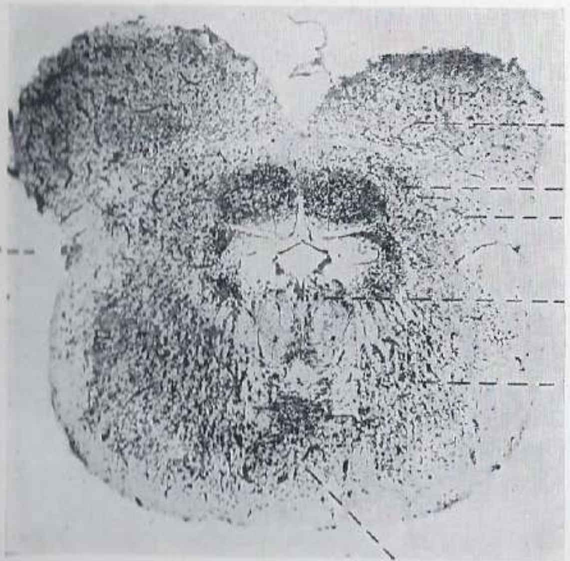


Fig. 23.

Fig. 22. Behind the above. The deepest layer of the tectum continues into the corpus quadrigeminum posterius, appearing laterally above the aquaeduct. In the deeper layer of the tectum, medially a few cells of the mesencephalic root of the trigeminus. Under the aquaeductus Sylvii we see the caudal continuation of the tegmental region of the preceding figure. In the median line, the medio-ventral group of cells of the nucleus oculomotorius, and more ventrally the ganglion interpedunculare. Laterally, thick clusters of reticular cells form the frontal continuation of the dorsal part of the ganglion isthmi (cf. fig. 73). Between this and the nucleus oculomotorius, lie two groups of cells, the mesial probably is a continuation of the nucl. ruber, the lateral being the nucl. profundus mesencephali of *Edinger* [1]).

Fig. 23. Behind the above. The corpora quadrigemina posteriora are more conspicuous and nearer the median line. Above them we find the posterior end of the tectum opticum and laterally from the corp. quadrigemina posteriora the ganglion isthmi which, further backward still increases. Laterally to the raphe the dorso-lateral group of the nucleus oculomotorius is visible, ventrally, in the median line, a part of the ganglion interpedunculare. Ventro-laterally from the nucleus oculomotorius the nucleus ruber.

[1]) *Edinger*. Studien über das Zwisschenhirn der Reptilien. Abh. der Senckenbergischen Naturf. Gesellsch. Frankfurt a. M. 1899.

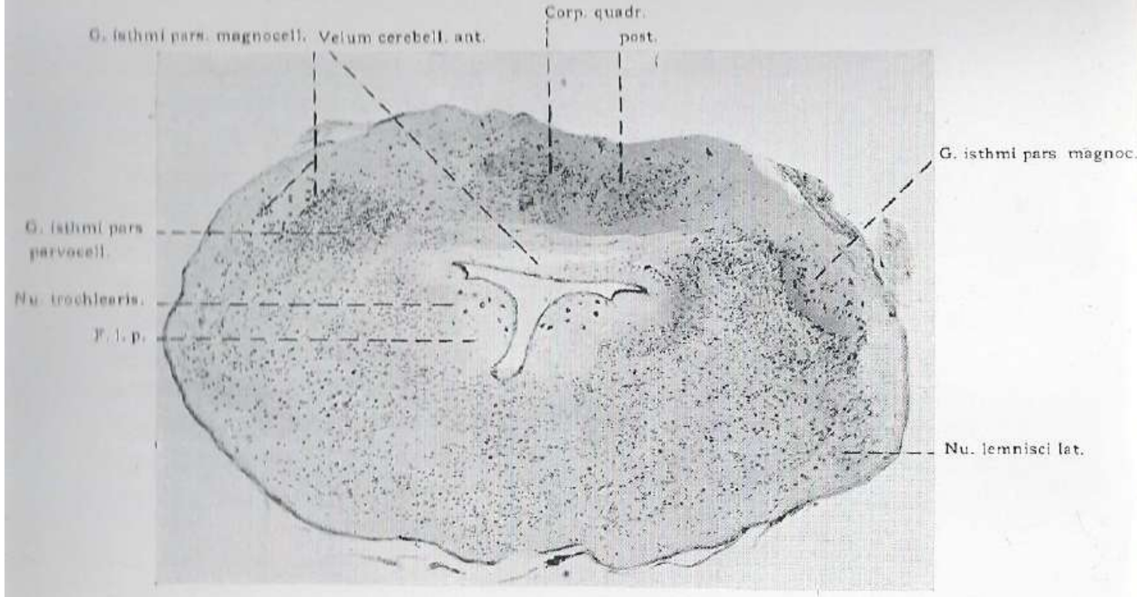


Fig. 24.

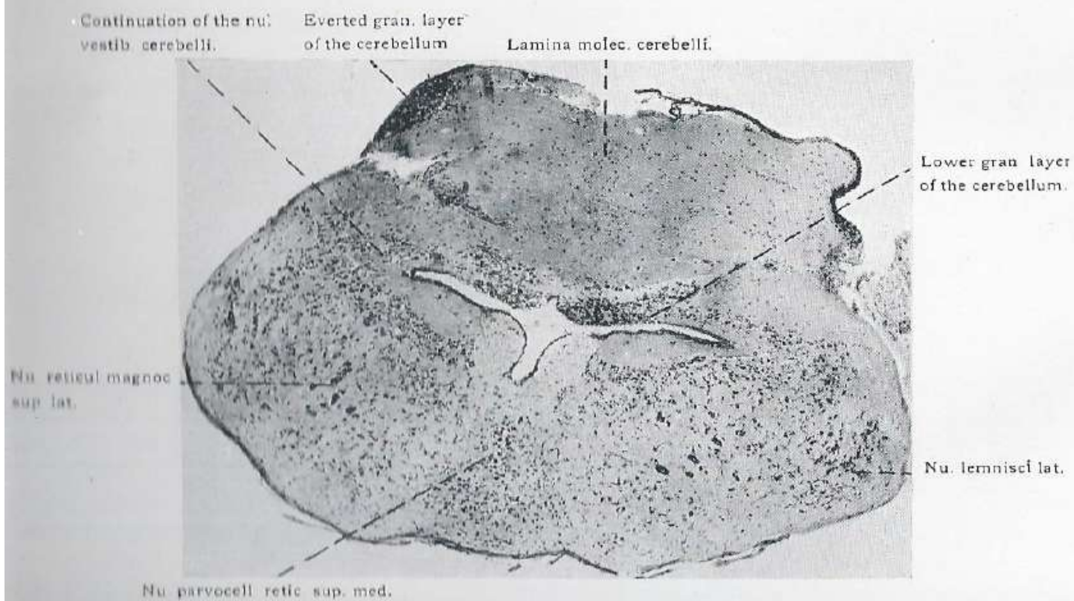


Fig. 25.

Fig. 24. Behind the former. In this section we find the most caudal portion of both corpora quadrigemina posteriora together with the velum cerebelli anterius. On either side the ganglion isthmi is seen, on the right only the portion with large cells, on the left both the magno-cellular and the parvo-cellular portion. Near the aquaeductus Sylvii on both sides the nucleus of the nervus trochlearis lies on the fasc. long. posterior, a small continuation of the aquaeduct separating the two nuclei, as is the case in other reptiles (Chameleon, Varanus, Testudo) and also in birds (Ciconia, *Kappers).* On the right, ventrolaterally, is the nucleus lemnisci lateralis, namely, its most frontal portion, which has shifted in the direction of the ganglion isthmi.

CEREBELLUM AND OBLONGATA.

Fig. 25. Behind the former. Here the cerebellum begins to appear. Dorsally the molecular layer is seen, and ventrally the granular layer. Latero-dorsally the laterally everted granular layer of the cerebellum is seen on the left. In the oblongata we observe the reticular nuclei, the upper medial with small cells as well as the upper lateral with large cells *(van Höevell*[1]*).* Lateral to the latter we find the continuation of the nucleus of the lateral lemniscus. The strand of cells connecting the cerebellum with the area statica may be regarded as a continuation of the nucleus vestibulo-cerebellosus.

[1]) *van Höevell.* Remarks on the reticular cells of the Oblongata in different vertebrates. Proceed. Kon. Akad. v. Wet. Amsterdam, 1911.

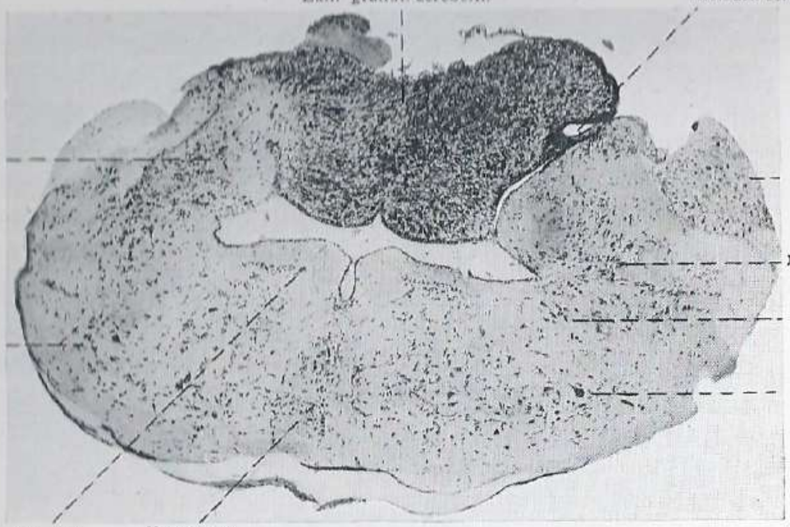


Fig. 26.

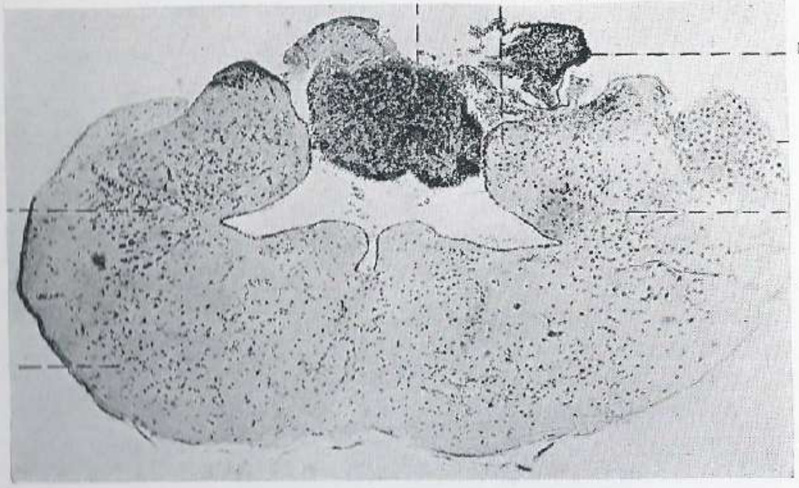


Fig. 27.

Fig. 26. Behind the former. On the right the incisura cerebelli lateralis, the environment of which may be indentified with the flocculus, as its granules border on the area statica. On the left a large cell group: the nucleus vestibulo-cerebellosus, which in Reptilia still lies beside the ventricle, but in the higher orders has shifted dorsally continuing into the cerebellum. This nucleus, which in mammals becomes the nucleus tecti cerebelli *(van Hoevell)* [1]) thus originally is no nucleus of the cerebellum. Laterally the first appearance (on the right) of the ggl. Scarpae, the ggl. of the first neuron of the nervus vestibularis. Medially lies the ascending nucleus of this nerve and ventrally from it the motor trigeminus nucleus. Whether the cells lying next to the fasc. long. posterior in the left half of the preparation is a frontal portion of the abducens I have not been able to determine with certainty. It seems quite possible though as in Varanus salvator *(Kappers)* [2]) the foremost portion of the abducens nucleus also reaches the caudal level of the motor trigeminus nucleus, which is seen here in the right part of the preparation. Lower down in the preparation the large cells next and the small cells in the raphe represent the reticular nucleus of this level *(van Höevell)*. Further laterally to the left the nucleus reticularis lateralis superior, in which some very large cells occur.

Fig. 27. Behind the former. The cerebellum, the granular layer and a lateral portion of which can still be seen, has become smaller. Medio-dorsally from the nucleus vestibularis adscendens the nucleus of the second neuron of the nervus acusticus: the nucleus cochlearis, comes into view. On the left we see the nucleus principalis vestibularis. Further the nucleus lemnisci lateralis which lies more medially than in the previous section.

[1]) The phylogenetic development of the cerebellar nuclei. Proceedings of the Koninklyke Academie v. Wetenschappen. Amsterdam 1916.
[2]) Weitere Mitteillungen über Neurobiotaxis, No. 7, Folia neurobiologica, Vol. 6, Sommer Ergänzungsheft, 1912.

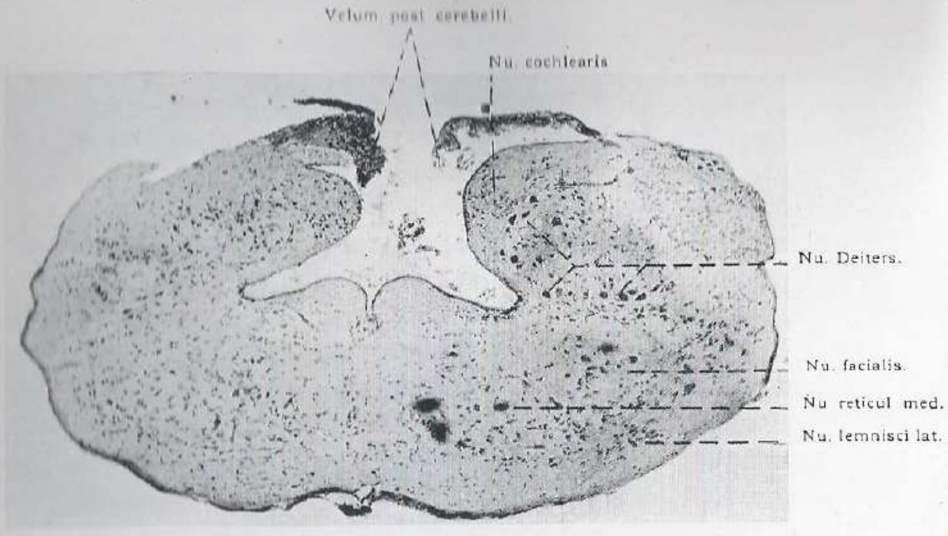


Fig. 28.

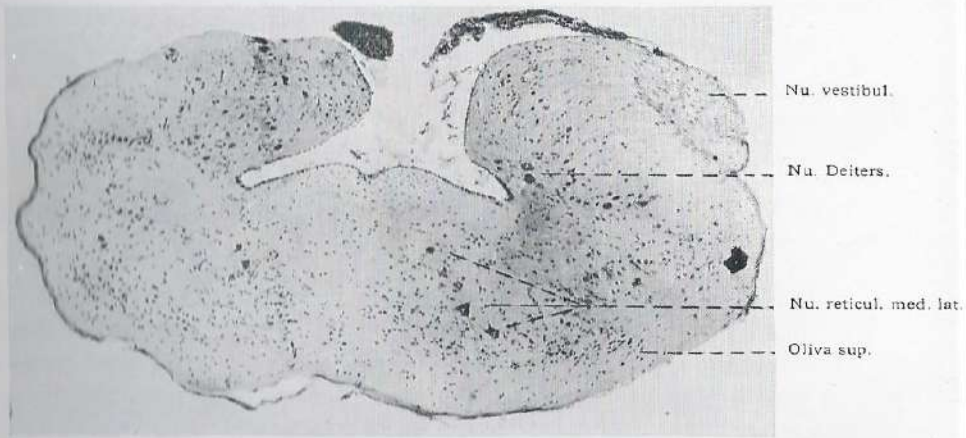


Fig. 29.

Fig. 28. Behind the former. The cerebellum has practically disappeared, only the posterior velum is still present.

Ventrally to the nucleus cochlearis the nucleus of Deiters with its large cells is visible, still more ventro-laterally the nucleus facialis. The nucleus reticularis medius with large cells lies deep in the middle of the medulla oblongata. The nucleus lemnisci lateralis as in the preceding section.

Fig. 29. Behind the former. The nucleus vestibularis (Deiters) appears again in this section, medially some very large cells of it occur near the wall of the fourth ventricle. Lower down, somewhat laterally from the mid line, the very large nucleus reticularis medius lateralis. Furthermore, ventro-laterally, the oliva superior, the cross section of which has somewhat the form of a foot; More frontally, the greater part of it disappears from the section, only its most lateral portion continuing in the nucleus of the lemniscus lateralis.

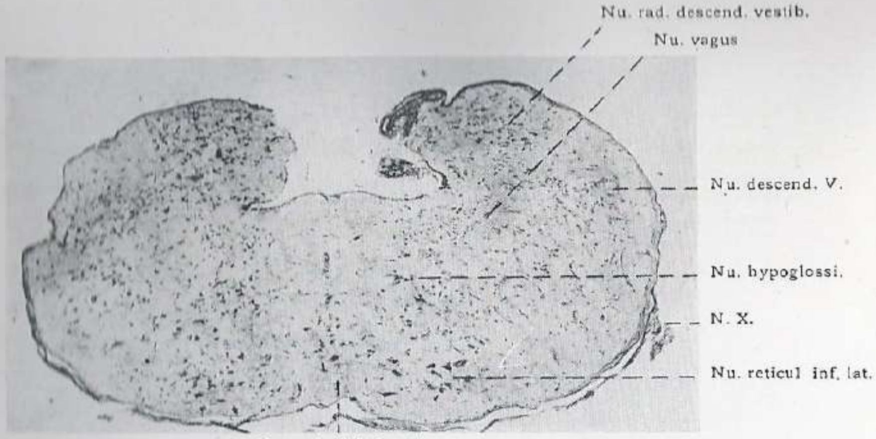


Fig. 30.

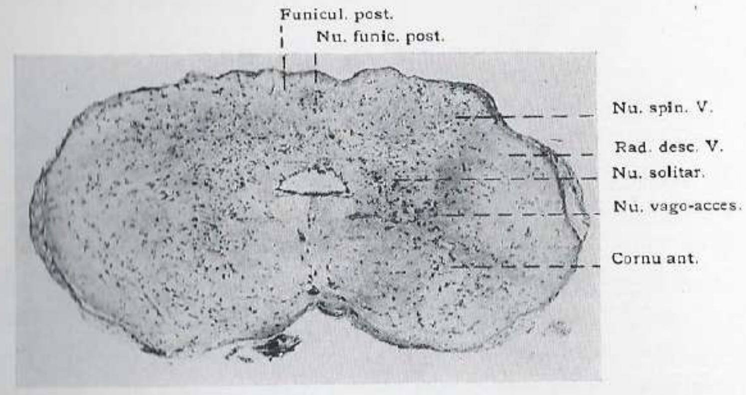


Fig. 31.

Fig. 30. Behind the former. In this section the nucleus of the descending vestibular root is seen dorsally, and rather more ventro-laterally the nucleus descendens trigemini. At a short distance from the angle of the ventricle there is a cell which might be a cell of the motor vagus nucleus. Medially, deep in the medulla lies the nucleus of the nervus hypoglossus and quite ventrally the interior medial and lateral reticular nucleus.

Fig. 31. Behind the former. Here we find the grey matter of the spinal V nucleus, separated by the funiculus post. from the nucleus funiculi posterioris in which no distinction in two nuclei (Goll and Burdach) can be made. Laterally the descending trigeminus root with its nucleus, quite medially the nucleus solitarius beside the central canal. Ventro-laterally of the latter the vago-accessorius nucleus. Also the beginning of the anterior horn: cornu anterius, lies in this section.

Fig. 32.

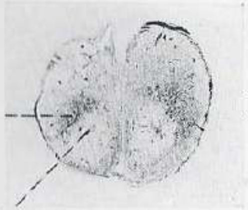


Fig. 33.

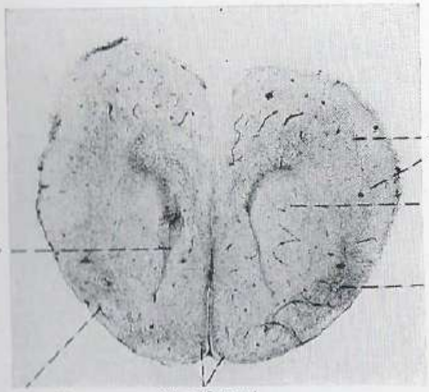


Fig. 34.

THE FIBRE TRACTS.

WEIGERT-PAL SERIES OF TRANSVERSE SECTIONS.

FOREBRAIN.

Fig. 32. A section of the lobus olfactorius anterior immediately behind the bulbus olfactorius, some bundles of fila olfactiva still visible dorso-medially. The myllinated axons of the mitral cells run in a bundle round the very narrow ventricle. The medial part of this bundle shall form a small tractus olfactorius medialis, the lateral part the large tractus olfactorius lateralis.

Fig. 33. Behind the above. A section through the frontal portion of the forebrain, in which ventrally in the pale round continuation of the lobus olfactorius the narrow ventriculus olfactorius may still be distinguished. The tractus olfactorius lateralis begins to radiate laterally, separating itself from the tractus olfactorius medialis.

Fig. 34. Behind the above. Here we find some fibres of the tr. cortico-archistriaticus, in addition to the fibres of the lateral olfactory tract. The former are tertiary olfactory fibres arising in the nucleus olfactorius lateralis and lateral cortex, in which the tractus olfactorius ends. Medially lies the tractus olfactorius medialis: direct fibres from the mitral cells, which run dorsally towards the frontal portion of the archicortex, and ventrally to the septum. Laterally from the ventricle the neostriatum is easily distinguishable by its paler hue.

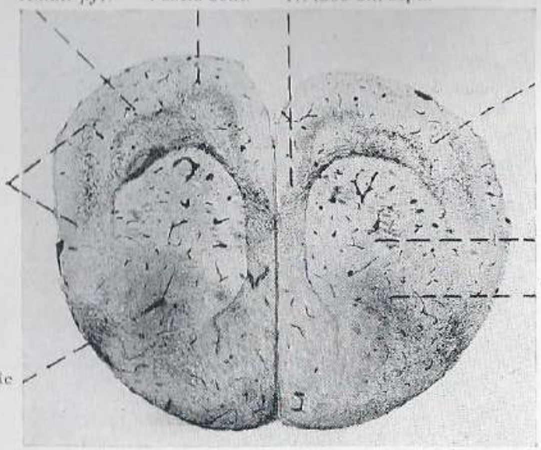


Fig. 35.

Fig. 35. Behind the above. Here, besides the very distinct cells of the dorsal archicortex with the medial and lateral overlapping: superpositio medialis and lateralis, we find the tractus lobo-olfactorius septi: the junction of the septal and mediobasal centra of smell with the medial cortex hippocampi. Moreover we see the lateral fibres of the tractus cortico-archistriaticus and centrally the radiation of the tractus thalamo-neostriaticus into the neostriatum, with its profusion of bloodvessels.

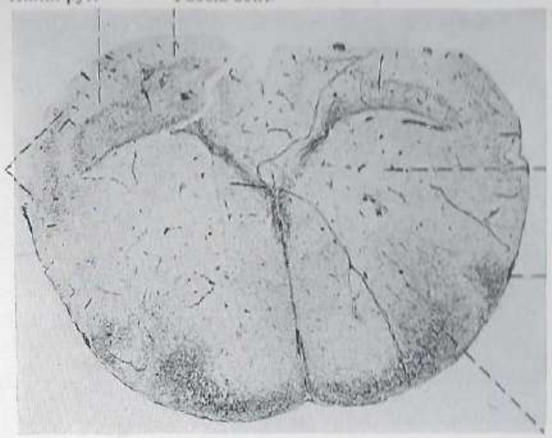


Fig. 36.

Fig. 36. Behind the above. The tractus thalamo-neostriatalis lies ventro-medially to the tractus cortico-archistriaticus some fibres of which start to finish in the archistriatum, a process more evident in the next section. Over this bundle some descending fibres from the archistriatum to the hypothalamus, tr. amygdalo-hypothalamicus of *William Herman*[1]). The tractus cortico-archistriaticus itself still lies quite laterally.

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[1]) *William Herman.* The relations of the corpus striatum and the pallium in Varanus and a discussion of their bearing on birds, mammals and man. Brain, Vol. 48, 1925.

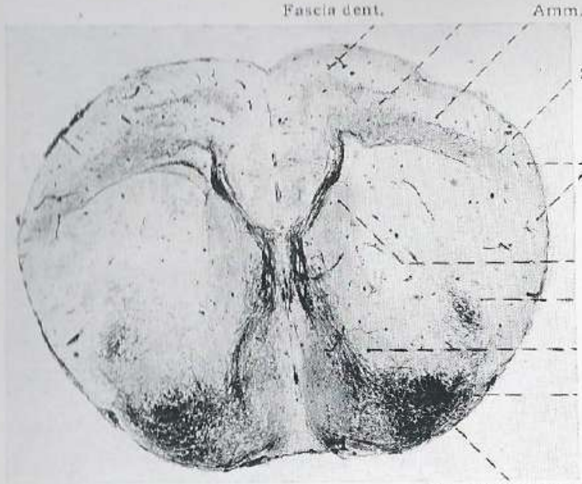

Fig. 37.

Fig. 37. Behind the above. This shows the medial radiation of the tractus cortico-archistriaticus. Further the ascending tracts of smell of the third order: the tractus lobo-olfactorius septi rectus, which forms with the descending fibres from the archicortex, (the tr. cortico-mammillaris or fornix and the tr. cortico-habenularis) the alveus hippocampi. The tractus thalamo-neostriatalis lies as a compact bundle at the bottom of the hemisphere. The tractus olfacto-habenularis runs ventrally along the latter.

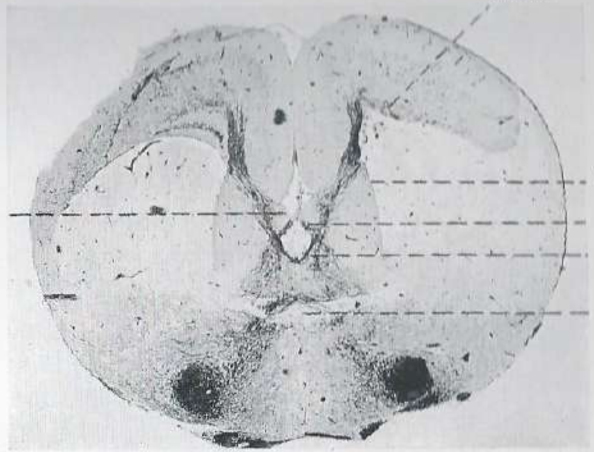

Fig. 38.

Fig. 38. Behind the above. Also here the tractus thalamo-neostriatalis can be clearly seen cut transversally through its entire width. The commissura pallii anterior has appeared in the same section, and forms a connection between the two hippocampi, fibres of which run into the alveus. The pale non myelinated or scarcely myelinated commissura interarchistriatica and the decussating tertiary tracts of smell: the tractus lobo-olfactorius septi cruciatus are also to be seen. Moreover we see fibres separating from the tractus lobo-olfactorius septi running backward through the superior part (pars fimbrialis) of the septum and form together a bundle in the shape of a knee. Under the pars fimbrialis septi we find two bundles extending from the median line ventro-laterally, one to the left and the other to the right: parts of the tractus lobo-olfactorius septi rectus.

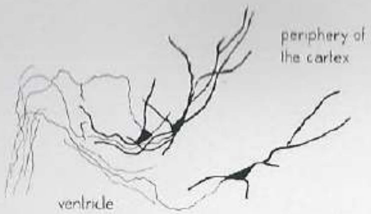

Fig. 64.

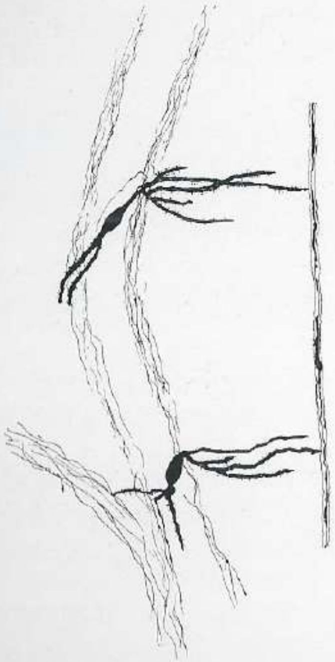

Fig. 65.

DRAWINGS OF GOLGI PREPARATIONS.

Fig. 64. Shows some large Ammon pyramid cells whose axons, originating from the cell body itself, run into the alveus. A single collateral can be seen not far from the cell. Most of the dentrites run peripherally in the direction of their afferent impulses (neurobiotaxis *Kuhlenbeck* [1]).

Fig. 65. This drawing shows some cells of the fascia dentata lying on the transverse level of the commissura palli anterior. The axons arise from a dendrite, not far from the cell. Near a cell the axon runs first dorsally, then turns and runs further ventrally. The axon of another cell runs directly in a ventral direction, probably to the nucleus lateralis septi (c. f. *Herrick)* [2]). Most of the long and very thick dendrites run medially to the cortex, a few run in a lateral direction. Note that processus moniliformes (sive spiniformes) occur on the dendrites, but on the main stem of the dendrites there are no processus. Most of the dendrites extend into the superficial layer of afferent fibres (fibrae superficiales, *Kappers*). Some of them, however, turn to the fibrae profundae of the afferent system. Both sorts of afferent fibres come from the tractus lobo- (or cortico-) olfactorius septi and pallial commissure.

---

[1]) *K. Kuhlenbeck.* Vorlesungen über das Zentralnervensystem der Wirbeltiere. Eine Einführung in die Hirnanatomie auf vergleichender Grundlage. Fischer, Jena, 1927.

[2]) *C. J. Herrick.* The morphology of the forebrain in Amphibia and Reptilia. Journ. of Comp. Neurology, vol. 20, 1910. —

Fig. 70.

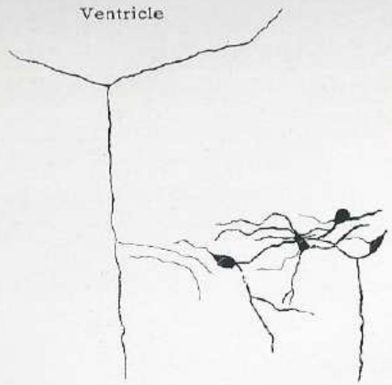

Fig. 72.

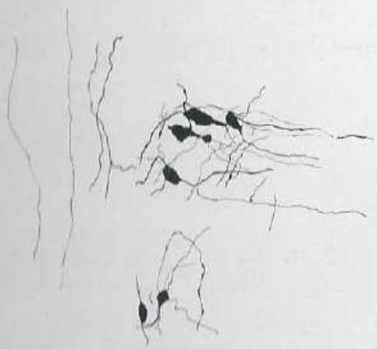

Fig. 71

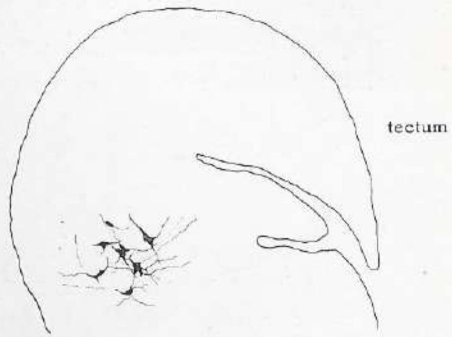

Fig. 73.

Fig. 70 shows cells of the ventral nucleus (underneath the nucleus rotundus, which has already disappeared in this section). The dendrites of this nucleus seem to run in the direction of the "triangular tract".

Fig. 71. Some round cells of the nucleus reticularis magnus tegmenti. The dendrites arise for the greater part on the medial side of the cell; soon afterwards they turn in a ventral direction almost parallel to the ventricle. On the lateral side of the cell body a strong dendrite or rather stem arises, giving origin to the axon which runs mainly laterally but also somewhat ventrally. Near it a few small oval cells (intercalating cells?).

Fig. 72. Cells of the nucleus ruber. They are large fusiform cells, which send their dendrites out in all directions. Their axons originate medially from the cell body. I have not been able to find any connection with the nucleus oculomotorius. The axones running medially form the origin of the decussated tractus rubro-spinalis, (cf. also *De Lange)* [1]).

Fig. 73. Cells of the frontal dorsal portion of the ganglion isthmi. They are polygonal in form. Axons, which arise from the cell body, run medio-dorsally in the direction of the torus semicircularis (sive corpus quadr. posticum). Other, also polygonal cells send their axons dorso-laterally towards the tectum opticum; one rather round cell, with dendrites extending in all directions, has an axon running in a lateral direction. I could not trace its connection. —

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[1]) *S. de Lange.* The red nucleus in Reptiles. Proceed. of the Kon Akad. van Wetensch. Amsterdam, April, 1912. —

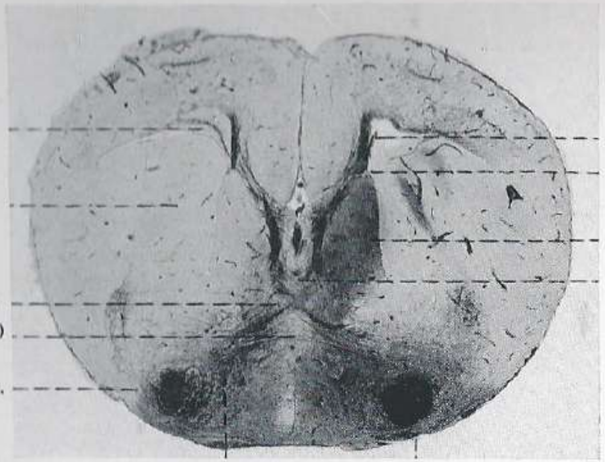

Fig. 39.

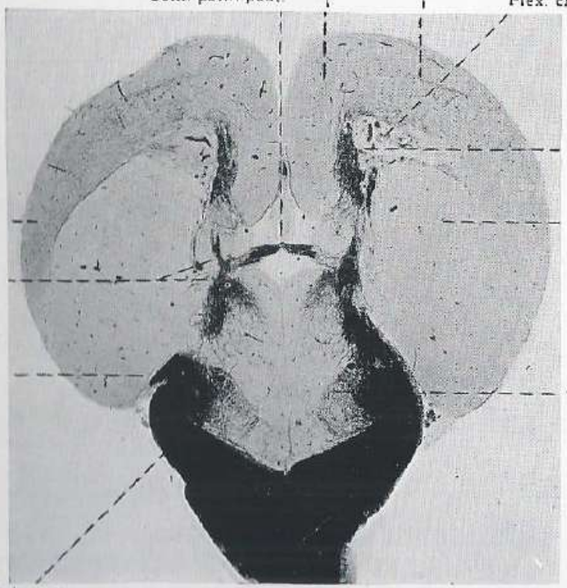

Fig. 40.

Fig. 39. Behind the above. The crossing of the commissura pallii ant. fibres has nearly disappeared from the section but the tractus olfactorius septi cruciatus is now to be seen for the greater part of its crossing course. Ventrally from it we find the forebrainpeduncles, to which join at the dorso-medial side the descending fibres from the septum, together with the tractus striatico-hypothalamicus. Periferally and clearly separated from it runs the tractus olfacto-habenularis. The commissura archistriatica (a part of the commissura anterior) is still recognizable being more faintly stained than the other fibres in this region.

Fig. 40. Behind the above. Dark fibres from the occipital part of the pallium cross in the commissura pallii post. Fibres of the tractus cortico-habenularis run together with the latter for some distance. Fibres of the fornix are seen turning ventro-medially. The tractus opticus with the chiasma encloses the ventral part of the thalamus in which is seen the forebrainpeduncle containing the tractus thalamo-neostriatalis and the descending fibres from the archistriatum and septum. At the left against the thalamus the tractus olfacto-habenularis on top of the tractus opticus. At the right the tractus olfacto-habenularis has joined the tractus cortico-habenularis, both forming together the taenia thalami. The alveus as in the preceding section.

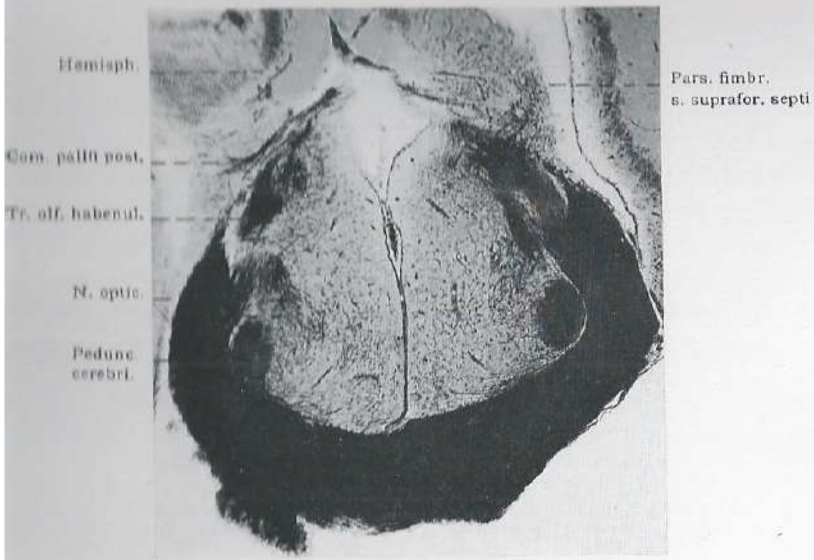

Fig. 41.

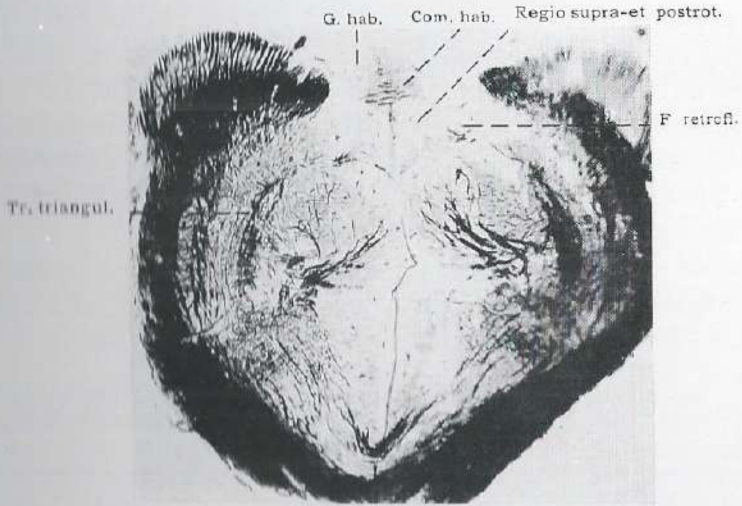

Fig. 42.

Fig. 41. Behind the above. The commissura pallii posterior still lies in the section but only its radiation towards the cortex. The pedunculus cerebri lies in the curve of the tractus opticus that has not yet reached the dorsal part of the thalamus. The fornix runs medio-ventrally.

Fig. 42. Behind the above. In this section we see the origin of the dorsal peduncle, the tractus thalamo-neostriatalis originating from the nucleus rotundus (and nucl. anterior). The tractus opticus enters the tectum opticum. At the left side the ganglion habenulae is fairly large; at the right it is hardly cut. At the caudo-ventral part of the ganglion habenulae the commissura habenularum. Dorsally from the tractus opticus the commissura supraoptica dorsalis (Meijnert). Dorsally from the nucleus rotundus the fasciculus retroflexus has just been cut. Laterally from the nucleus rotundus we find a bundle of fibres issuing from the region of the nucleus lentiformis (praetectalis), just under the tectum laterally to the nucleus anterior. This tract runs in a slight curve round the nucleus rotundus ventrally; it has a triangular form in some sections and it may therefore be named provisionally: "tractus triangularis". Its origin could not be determined, perhaps it is a tractus praetecto-spinalis.

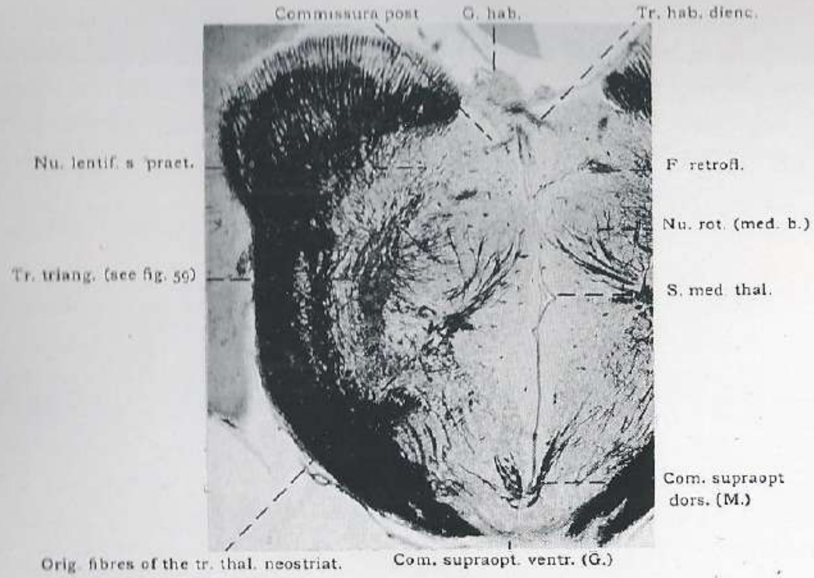

Fig. 43.

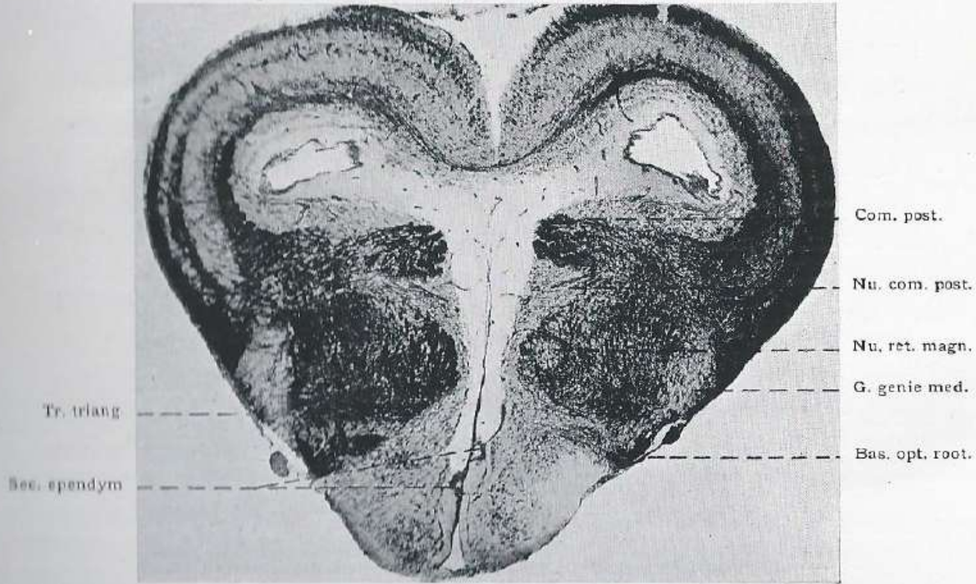

Fig. 44.

Fig. 43. Behind the above. In this section the left ganglion habenulae is still very clear, the commissura habenulae is also still present. The "tractus triangularis" is very strong. Originating fibres of the tractus thalamo-neostriatalis are to be seen chiefly in the medial portion of the nucleus rotundus, (the nucleus rotundus medialis b). Above the nucleus rotundus we find the fasciculus retroflexus cut transversally. In the wall of the ventricle the sulcus medialis thalami is clear. In the ventral part of the thalamus both commissurae supraopticae are very distinct, viz: the dorsal (Meijnert's) and the ventral (Gudden's), the latter also known by the name of commissura transversa.[1]) Above the fasciculus retroflexus a very small but distinct myelinated bundle runs ventrally in an analogous way as the fasciculus retroflexus itself, terminating, however, in the upper nucleus of the 'tween brain (nucleus anterior). It is the tractus habenulo-diencephalicus. This section being behind the stalk of the epiphysis, this tract borders immediately on the commissura posterior, the left side of which begins to appear in the section.

Fig. 44. Behind the above. In this section which passes through the tectum opticum, behind the commissura posterior, we see the fibres of this commissure cut at both sides and radiating into the the nucleus commissurae posterioris. Ventrally from this nucleus the nucleus reticularis magnus is to be seen and quite laterally, at both sides what may be a primitive ganglion geniculatum mediale. Especially at the left side the cross-section of the "tractus triangularis", mentioned above is distinct. Ventrally to the level of the sulcus medius in the wall of the ventricle the secreting ependym (cf. *Charlton)*[2]) has been cut. The basal opticus root (*Edinger*, *Huber* and *Crosby*, and *Kuhlenbeck* l. c.) is visible, on the left as well as on the right.

[1]) See for the constituents of these commissures *Huber* and *Crosby*. Journ. of Comp. Neurology Vol. 27, 1917.

[2]) *Charlton*. Proceed of the Kon. Akad. v. Wetensch. 1929.

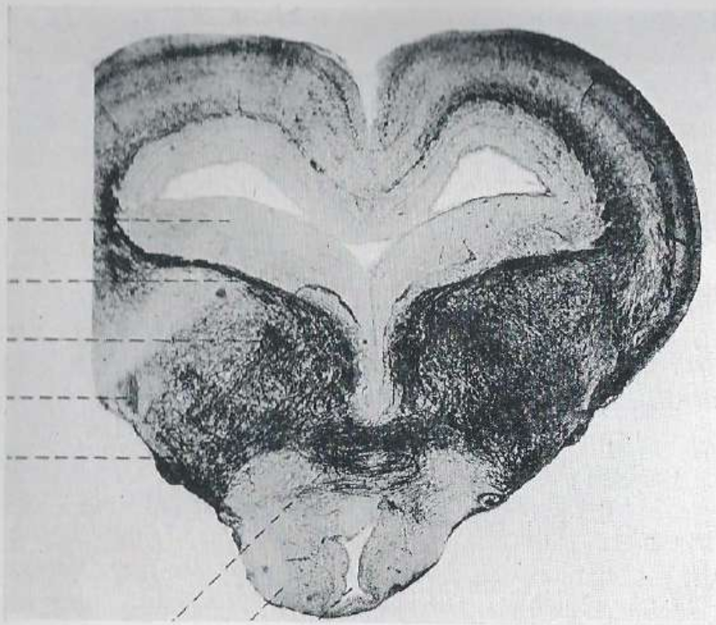

Fig. 45.

Fig. 45. Behind the above. The frontal part of the torus semicircularis (s. corpus quadrigeminum posterius) is to be seen lying under the middle part of the tectum opticum. From of the tectum opticum the tractus tecto-mesencephalicus et bulbaris dorsalis, originates. Laterally we find the caudal part of the commissura supraoptica ventralis (s. commissura transversa) and the basal opticus root and ventrally the commissura post-infundibularis.

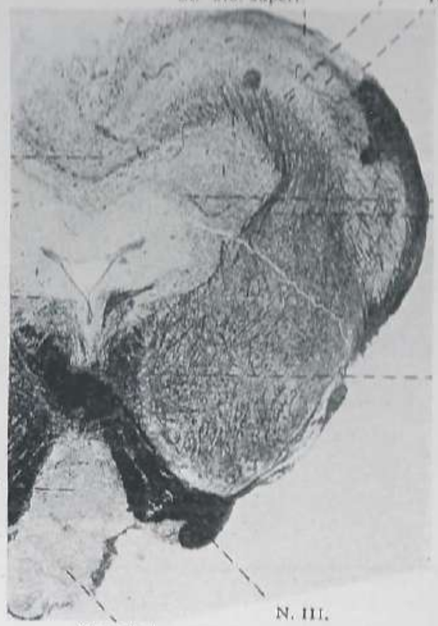

Fig. 46.

Fig. 46. Behind the above. In this section the oculomotorius root is cut, below the decussation of the tractus tecto-bulbaris dorsalis which decussation lies more frontaly than that of the tractus tecto-bulbaris ventralis (*S. de Lange*, l. c.). Near the nucleus oculomotorius the fasciculus longitudinalis posterior, cut transversally, and dorso-medially a nucleus of that bundle. Laterally from the root of the oculomotorius, in the tegmentum mesencephali, the red nucleus. In the deep layer of the tectum opticum a cell of the mesencephalic nucleus of the nervus trigeminus is seen.

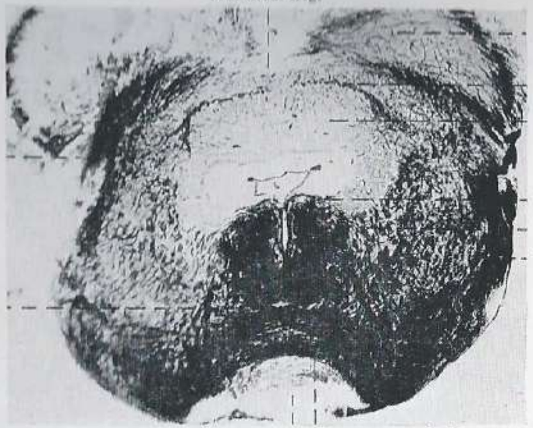

Fig. 47.

Fig. 47. Behind the above. Here the caudal part of the tectum opticum has been cut, under which lies the broadest part of the corpus quadrigeminum posterius, that began as torus semicircularis in fig. 45. Here it is dorsally bordered by the fibres of the midbrain root of the trigeminus. Dorso-medially some cells of this trigeminus root may be distinguished. Ventrally from the aquaeduct lies the nucleus nervi trochlearis and below it, immediately under the fasciculus long. posterior, the anterior part of the decussatio brachii conjunctivi cerebelli. Quite ventrally we find the decussatio tecto-bulbaris ventralis (Forel's decussation) and under it the ganglion interpedunculare. Laterally lies the tractus octavo-mesencephalicus (or lemniscus lateralis) and tractus spino-mesencephalicus.

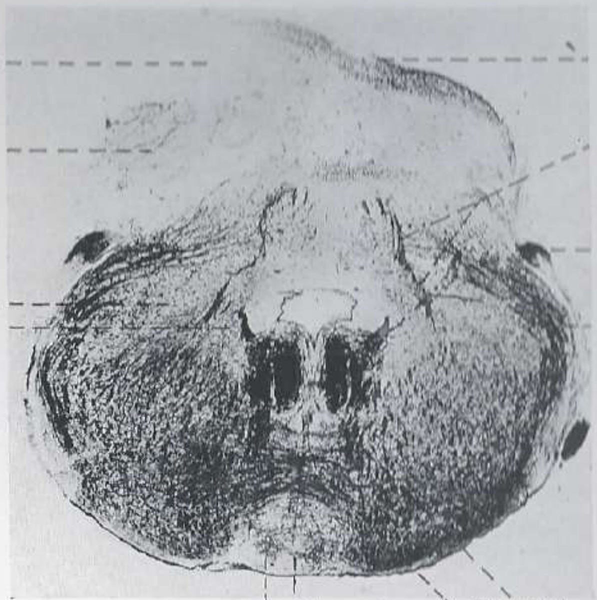

Fig. 48.

Fig. 48. Behind the above. Hardly anything is left of the tectum opticum and little of the corpus quadrigeminum posterius, but the exverted cerebellum is now seen. Also the fibres of the mesencephalic root of the trigeminus and the nucleus trochlearis are visible. The tractus spino-mesencephalicus and the tractus octavo-mesencephalicus run round the ganglion isthmi in a latero-dorsal direction. Ventrally from the fasciculus longitudinalis posterior lies the decussatio brachiorum conjunctivorum. The tractus mammillo-bulbaris has been cut transversally in the region of the ganglion interpedunculare.

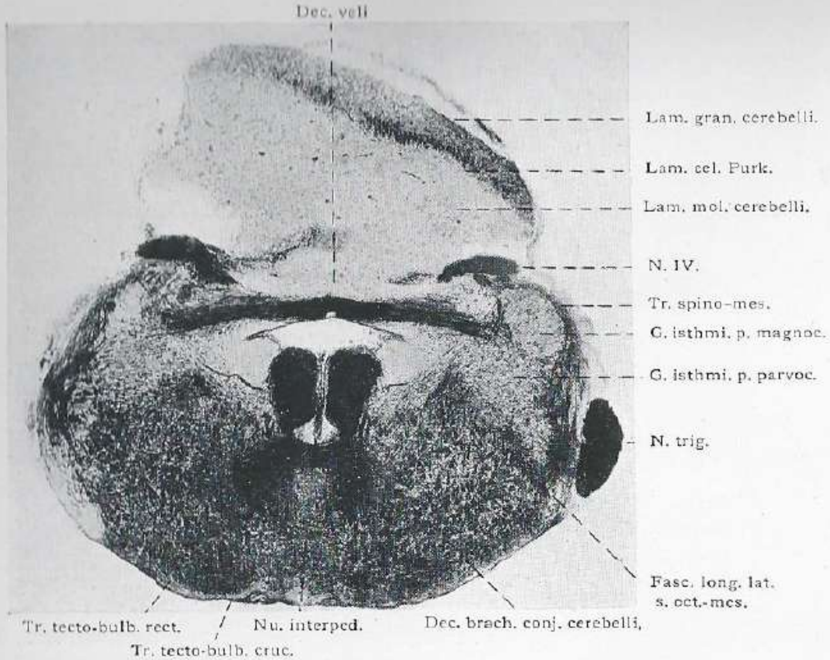

Fig. 49.

Fig. 49. Behind the above. This section goes through the decussatio veli at the frontal boundary of the medulla oblongata. In the exverted cerebellum the granular and molecular layers are to be seen, separated by the layer of Purkinje's cells. Between the layer of Purkinje's cells and the granular layer we find the medullary layer of the cerebellum. Dorsally from the aquaeductus Sylvii lies the decussatio veli, a decussation consisting chiefly of fibres of the tractus spino-cerebellaris. The tractus spino-mesencephalicus encloses the protruding pars magnocellularis of the ganglion isthmi. On both sides the nervus trochlearis turns medially into the direction of its decussation, which lies in the middle of the decussatio veli. The nervus trigeminus and the fasciculus longitudinalis lateralis (s. tractus octavo-mesencephalicus s. lemniscus lat.) are both cut transversally. Ventrally from the fasc. long. posterior lies the decussatio brachiorum conjunctivorum, which at this level attains its greatest development. Ventrally from it are some vestiges of the ganglion interpedunculare. The fibres of the tractus tecto-bulbaris cruciatus have all decussated now and run backward right and left to the ganglion interpedunculare. Beside them lies the tractus tecto-bulbaris rectus.

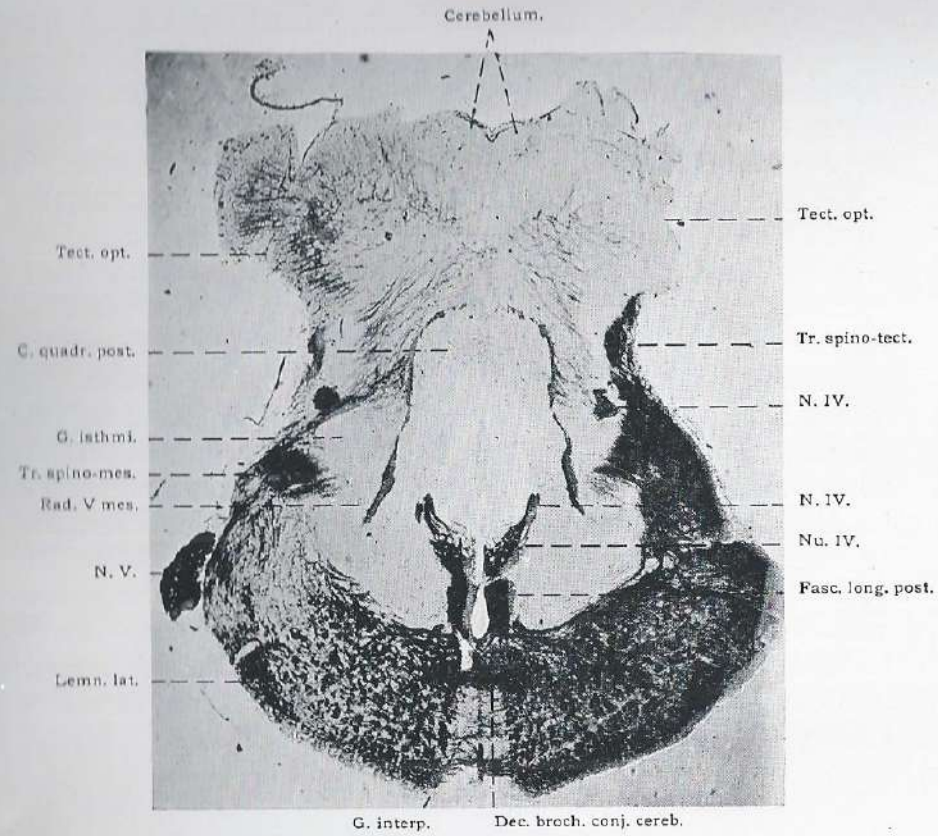

Fig. 50 (of another series than fig. 49).

Fig. 50. Behind the former. This section shows the nucleus trochlearis and the root fibres which leave the nucleus. Much more dorso-laterally the fibres of the trochlearis root are once more cut, now transversely; in the immediate proximity of the latter the tractus spino-tectalis is seen ascending. On both sides vestiges of the tectum opticum can still be seen, in the middle of it a small portion of the cerebellum. Both right and left the mesencephalic trigeminus root is seen running for a considerable distance round the corp. quadr. post., while on the left the motor trigeminus root is also clearly visible. Similarly the lemniscus lateralis: the connection of the nucleus cochlearis with the contralateral corp. quadr. post. and the ganglion isthmi. The fibres of the lemniscus lateralis are distinct from those of the tractus spino-mesencephalicus by their greater thickness and darker stain. Beneath the fasc. longitudinalis posterior the decussatio brachii conjunctivi.

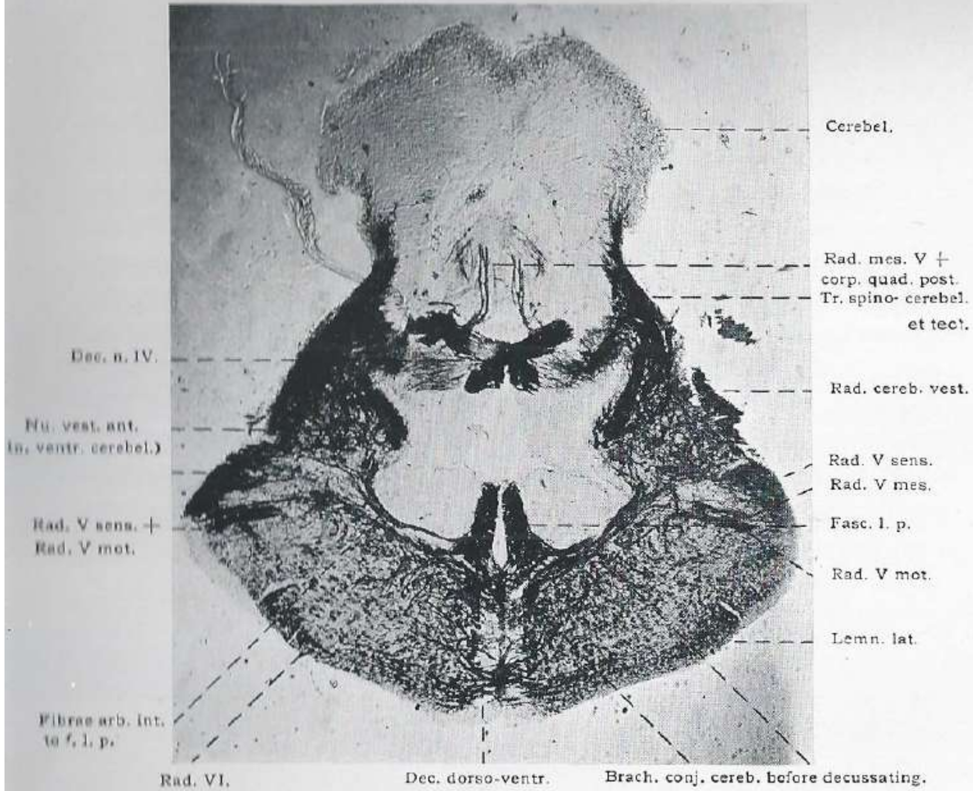

Fig. 51.

Fig. 51. Behind the former. The tectum opticum has entirely disappeared. The cerebellum is visible but still encloses — under the dotted line — a portion of the corp. quadrigemina posteriora. The section goes through the decussation of the nervus trochlearis. The tractus spino-cerebellaris radiates into the cerebellum. On both sides the eminentia ventralis cerebelli (*Herrick*[1]) is seen lying in the wall of the ventricle. It is from its nucleus that the nuclei of the cerebellum in birds and mammals develop. From this nucleus, too, there develops here, just as with birds and mammals, the brachium conjunct. cerebelli. These fibres at first run as fibrae arcuatae dorsales together with analogous fibres from the vestibular nuclei (see left) to the f.l.p. in analogy with the tractus cerebello- et vestibulomotorius of fishes (*Kappers*) and the "innere Abtheilung des Kleinhirnstiels" in mammals (*Fuse*[2]). Whereas the vestibulo-motor fibres run in the f.l.p., the brachium conjunctivum runs below it. The right side shows more clearly than the left fibres running towards the cerebellum: the radix vestibularis cerebellaris. Most probably these fibres synapse with the dendrites of the Purkinje cells (climbing fibres). More laterally the sensory and the motor root of the trigeminus is seen emerging from the oblongata. Between these two roots of the trigeminus the radix mesencephali quinti lies, joining the motor root (*van Valkenburg*[3]). That its fibres join the motor branch of this nerve must be explained to the fact that they act as conductors of muscular sensation (*Willems*[4]). Quite ventrally a small dorso-ventral decussation of fibres which may form part of the brachium conjunctium (see also fig. 50). At the bottom, to the left a small abducens root runs, medially to the lemniscus lateralis.

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[1]) cf. *Herrick*. The cerebellum of Necturus and other Urodele Amphibia. Journ. of Comp. Neur. Vol. 24, 1914.

[2]) *Fuse*. Die innere Abteilung der Kleinhirnstiels (Meynert I. A. K.) und der Deitersche Kern. Arbeiten a. d. Hirnanat. Intitut in Zürich, Heft VI, 1912.

[3]) *Van Valkenburg*. Zur vergleichenden Anatomie des Mesencenphalen Trigeminus anteils. Folia Neurobiologica, Bnd. V, 1911. —

[4]) *Willems*. Localisation motrice et kinesthésigue. Les noyaux masticateur et mesencephalique du trijumeau chez le lapin. Névraxe, 1911.

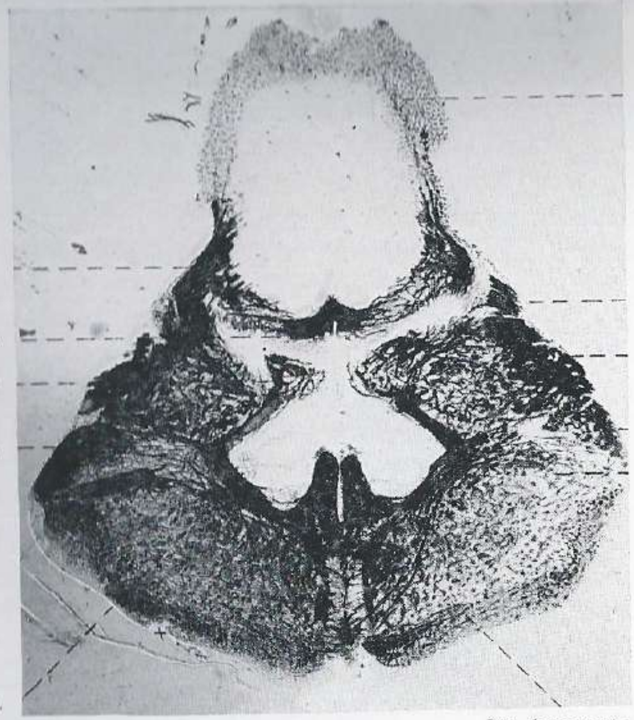

Fig. 52.

Fig. 52. Behind the former. Immediately behind the trochlearis decussation the lamina medullaris inferior cerebelli, a continuation of the decussatio veli, and largely consisting of decussated spino-cerebellar fibres. Below the lamina medullaris inferior the nucleus cochlearis. This section further shows some direct spino-cerebellar fibres probably together with olivo-cerebellar fibres radiating into the cerebellum. On the right side the radix cochlearis and the radix vestibularis emerge, the former more dorsally than the second. — More ventrally the sensory descending and motor trigeminus root, the latter still accompanied dorsally by a few fibres of the radix mesencephalica trigemini. The fibrae arcuatae dorsales, which here also contain some fibres from the nucleus cochlearis, and the small dorso-ventral decussation as in the previous section.

On the left and right the magnocellular cochlearis nucleus is very distinct. Dorsal arcuate fibres originate from it, running to the fasc. long. posterior. The second cochlearis nucleus, nucl. angularis, is not visible in this section. It lies somewhat more frontally. —

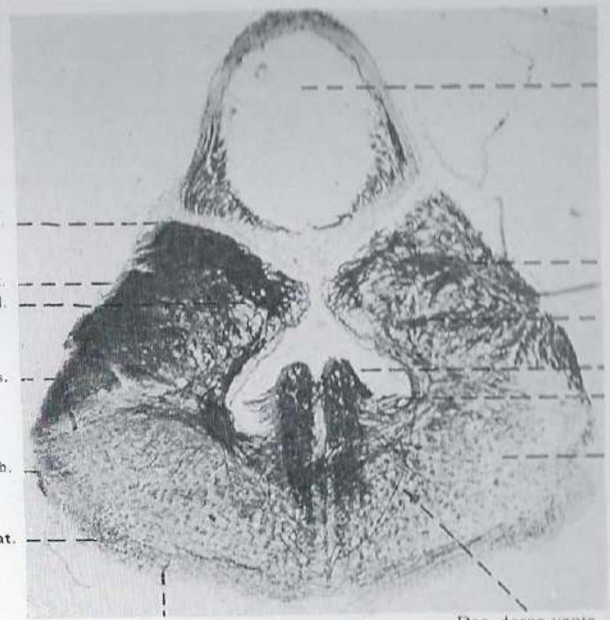

Fig. 53.

Fig. 53. Behind the former. On the left the junction of the radix cochlearis with the nucl. magnocellularis cochlearis can be seen. On the right below the radix vestibularis descendens the entrance of the sensory facialis root, which runs towards the lateral wall of the ventricle. Latero-ventrally to the fasc. long. post. the motor facialis root. Laterally on the left the tractus spino-cerebellaris and tectalis, and latero-ventrally the tractus vestibulo-spinalis lateralis, probably mixed with tecto-bulbar fibres.

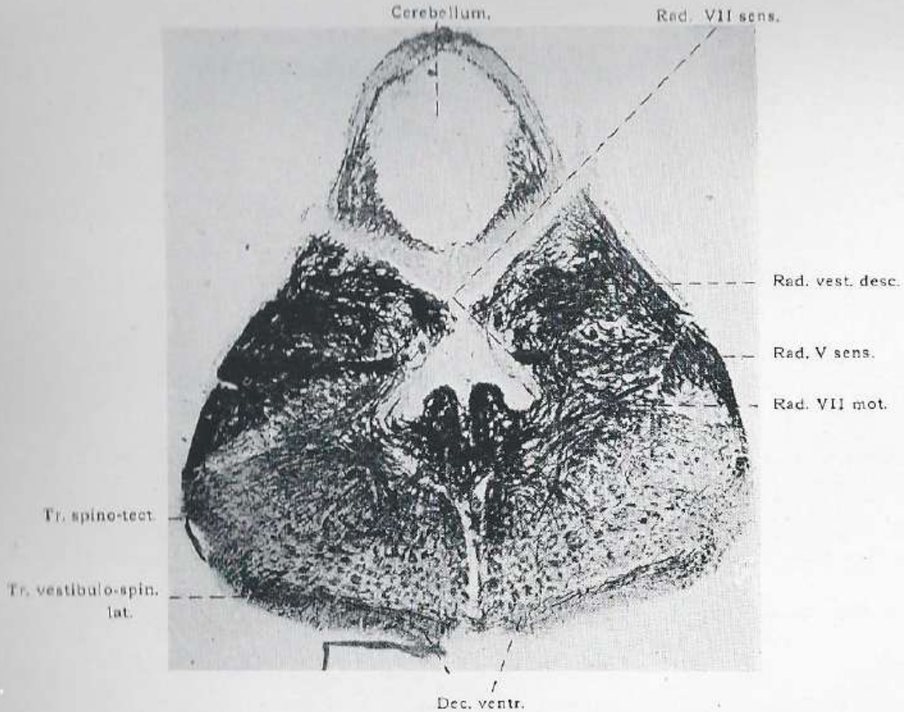

Fig. 54.

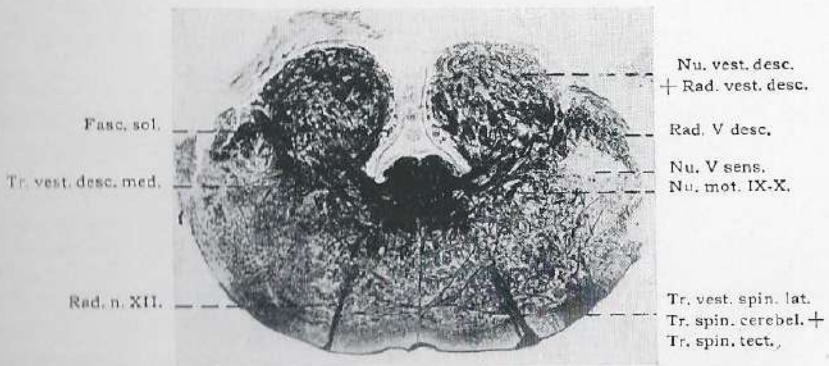

Fig. 55.

Fig. 54. Behind the former. In this section the sensory facialis root is seen on both sides, the motor root only on the right. Dorsally, left of the ventricle the radix descendens vestibularis, and laterally the sensory descending trigeminus root. Some decussating fibres from the vestibular nucleus: tractus vestibularis descendens lateralis or tractus vestibulo-spinalis, run in the ventro-lateral division of the medulla oblongata, occupying a similar position as the lemniscus lateralis does on frontal sections. This area probably also contains tecto-bulbar fibres.

Fig. 55. Behind the former. The darker fibres on the dorsolateral side are those of the spinal trigeminus root running towards the posterior horn. Medially to these the descending vestibular fibres from which area some fibrae arcuatae internal join the f.l.p. Between these and above the f.l.p. the tractus solitarius with its nucleus. Quite laterally can be seen the tractus spino-cerebellaris et-tectalis. On either side of the midline the most frontal rootlets of the nervus hypoglossus. Laterally of these the vestibulo-spinal tract lying next to the spino-tectal tract.

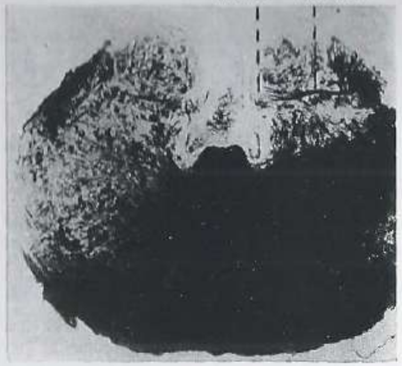

Fig. 56.

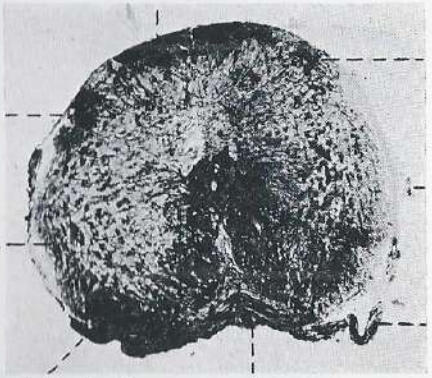

Fig. 57.

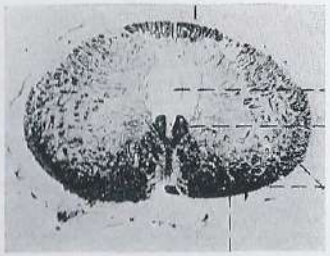

Fig. 58.

Fig. 56. Behind the former. This section has been selected only to show the course of the sensory vagus fibres to the tractus and nucleus solitarius.

Fig. 57. Behind the former. In this section, which forms the transition of the medulla oblongata to the medulla spinalis, we see on the left the last fibres of radix descendens trigemini joining the posterior horn (nucl. spinalis trigemini). Further the tractus spino-mesencephalicus et cerebellaris and the tractus vestibulo-spinalis lateralis [1]). Laterally the emergence of the nervus accessorius is visible, as well as a R. dorsalis and a R. ventralis spinalis. This section also shows the small size of the posterior funiculus in these animals, where according to *Brouwer's* interesting researches [2]) it only forms 10,4 % of the total white substance on this level.

Fig. 58. Behind the former, shows approximately the same relation as fig. 57 as far as concerns the spinal tracts. —

[1]) Medial vestibulo-spinal fibres run in the fasciculus longitudinalis posterior.

[2]) *Brouwer*. Die biologische Bedeutung der Dermatomerie Folia Neurobiologica, Bnd. IX, 1915.

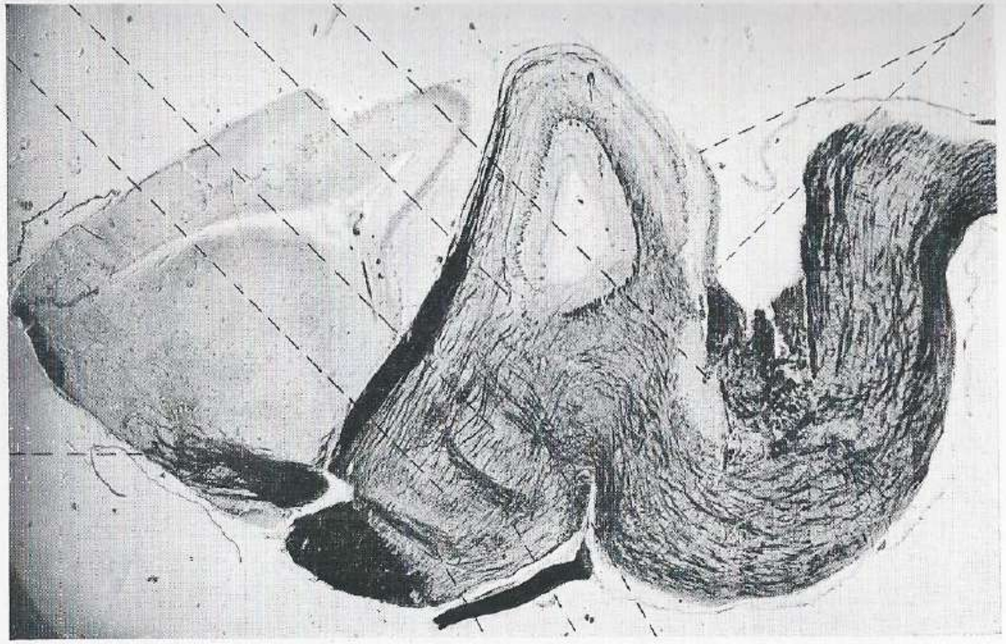

Fig. 59.

WEIGERT-PAL SERIES OF SAGITTAL SECTIONS.

Fig. 59. This section shows the tractus striato-hypothalamicus [1]) or ventral peduncle, which, as appears from other preparations runs on as far as the level of the nucleus oculomotorius, perhaps even farther. More dorsally, immediately on top of it in the forebrain the thalamo-neostriatal fibres run.

Under the nucleus rotundus runs through the ventral thalamus the above mentioned "tractus triangularis", which passes on frontally as far as the nucleus lentiformis (sive praetectalis). More than in the transverse sections it makes the impression to be a spino-praetectal [2]) tract. Upon the chiasma, and between this and the ventral peduncle lies the commissura transversa (Gudden's commissure), cut obliquely. Behind the nucleus rotundus the fibres of the commissura posterior. The brachium conjunctivum can be seen running ventrally out of the cerebellum. Within the anterior portion of the tectum opticum, where this passes into the thalamus, lies the nucleus praetectalis (lentiformis, *Edinger)*, cut transversally, between the deep fibres of the tectum.

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[1]) This tract seems to contain also fibres originating in the frontoventral wall of the heurisphere.

[2]) Or praetecto-spinal tract, considering its strong myelinisation.

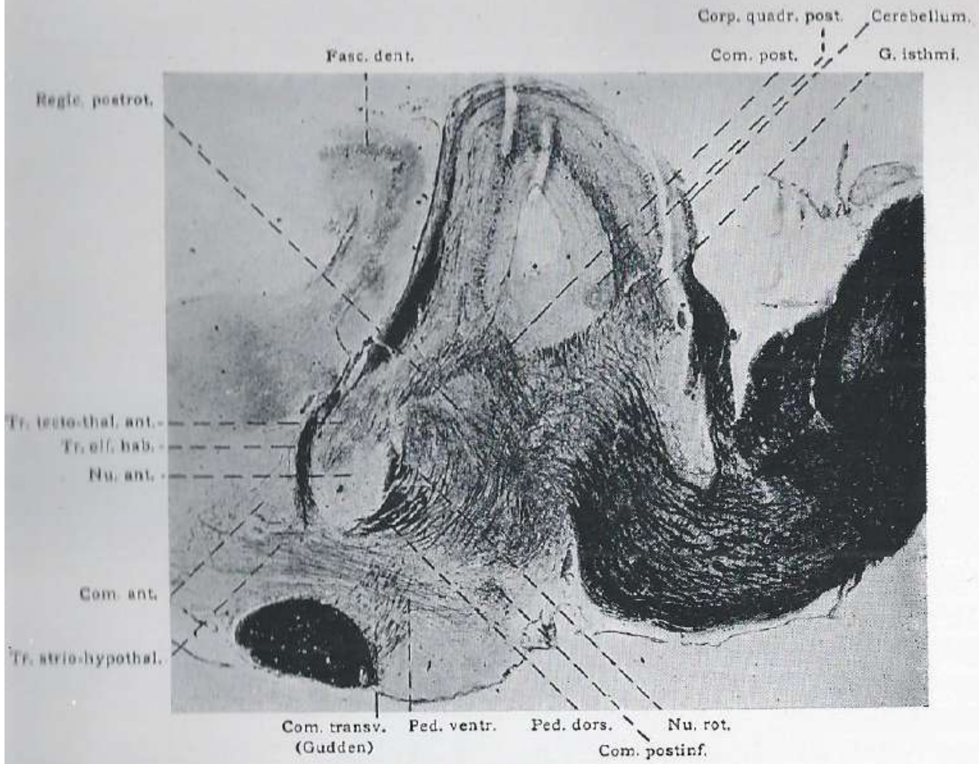

Fig. 60.

Fig. 60. Shows the fibres, which come from the nucleus anterior (and rotundus) running frontally to the neostriatum: the dorsal peduncle or tractus thalamo-neostriatalis *(Kappers)*. The nucleus anterior seems to be connected also with the tectum by a tr. tecto-thalamicus anterior. In the ventral thalamus behind the infundibulum we see the commissura postinfundibularis cut transversally. Frontally, above the chiasma nervi optici, the commissura transversa, crossing the ventral peduncle. At the caudal end of the tectum lie the corpus quadrigeminum posterius and the ganglion isthmi, immediately behind each other, the former protruding into the ventral part of the tectum.

The position of the cerebellar plate, bending frontally against the midbrain roof, is clearly seen. —

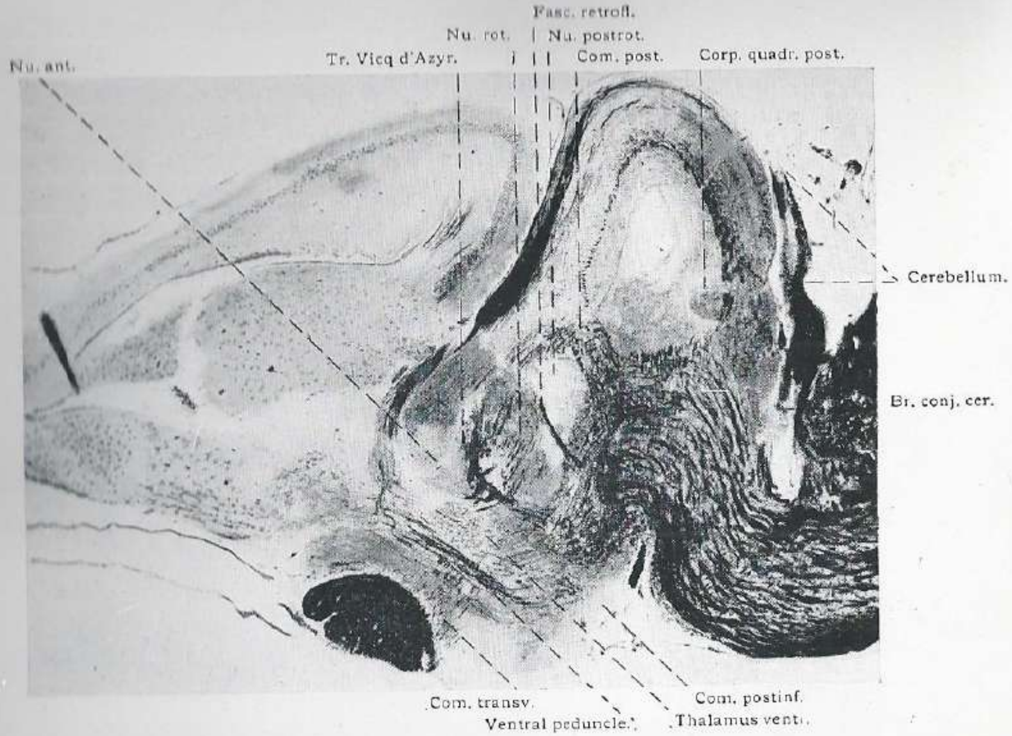

Fig. 61.

Fig. 61. In this section the division into dorsal and ventral thalamus is very clear, the boundaryline being indicated by the lower border of the nucleus rotundus. This nucleus is bounded dorsally by the fasciculus retroflexus. Fibres of some mammillo-thalamic connection, that join the hypothalamus to the nucleus anterior, are to be seen between the nucleus rotundus and the nucleus anterior thalami. I did not however succeed in finding a real corpus mammillare in which these fibres might arise: the cells of their origin are diffusely scattered within the posterior region of the hypothalamus as already described by *de Lange.*[1]) Above and behind the nucleus rotundus runs the fasciculus retroflexus, which may be traced ventro-caudally close to the oculomotorius root, ending in the ganglion interpedunculare. The regio supra-et postrotunda covers dorsally and caudally the nucleus rotundus extending backward unto the commissura posterior. This region (cf. also fig. 42 and 43 and 16 to 19) contains the lentiform nucleus and continues backward into the spiriform nucleus that lies between the fibres of the posterior commissure. As the latter nuclei belong to the midbrain (to the metathalamic part of the midbrain) the fasciculus retroflexus serves as a boundary line between the thalamus proper and this region.

[1]) *S. de Lange.* Das Zwisschenhirn und das Mittelhirn der Reptilien Folia Neurobiolcgica, Bnd. VII, 1913. —

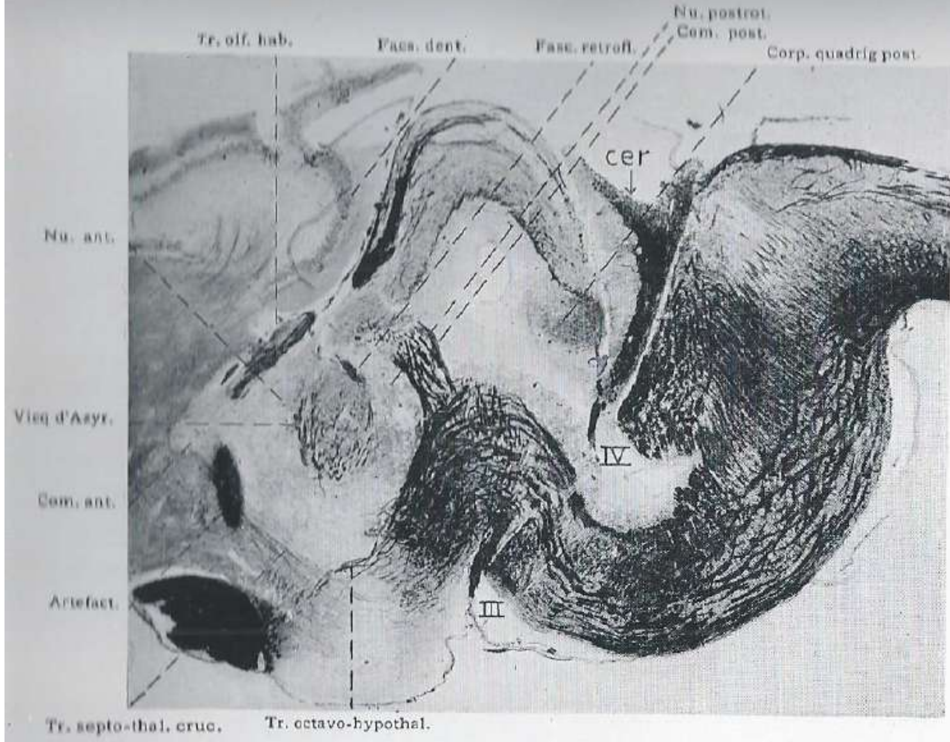

Fig. 62.

Fig. 62. In this section the taenia thalami fibres have been cut in their ascending course above the nucleus anterior, slightly more dorsally than in fig. 41. We see the thin fibres of the tractus septo-hypothalamicus cruciatus issue from the pale round comm. archistriatica and then bend and go as far as that portion of the hypothalamus, which lies just behind the tractus opticus. There these fibres cross those of the tractus octavo-hypothalamicus, a bundle which forms the connection between the vestibular nuclei of the oblongata and the anterior hypothalamus, first running in the fasciculus long. posterior and frontally turning ventrally, behind the chiasm as described by *Wallenberg* [1]) in Birds. Exactly dorsally to the fasc. long. posterior, partly in it, the nucleus trochlearis, the root of which runs in a dorsal direction. Frontally and ventrally the oculomotor nucleus and root.

[1]) *Wallenberg*. Die sekundäre Octovusbahn der Taube. Anat. Anzeiger, Bnd. 14, 1898 and *Wallenberg* Ueber die zentralen Endstätten des N. Octavus bei der Taube Ibidem, Bnd. 17, 1900.

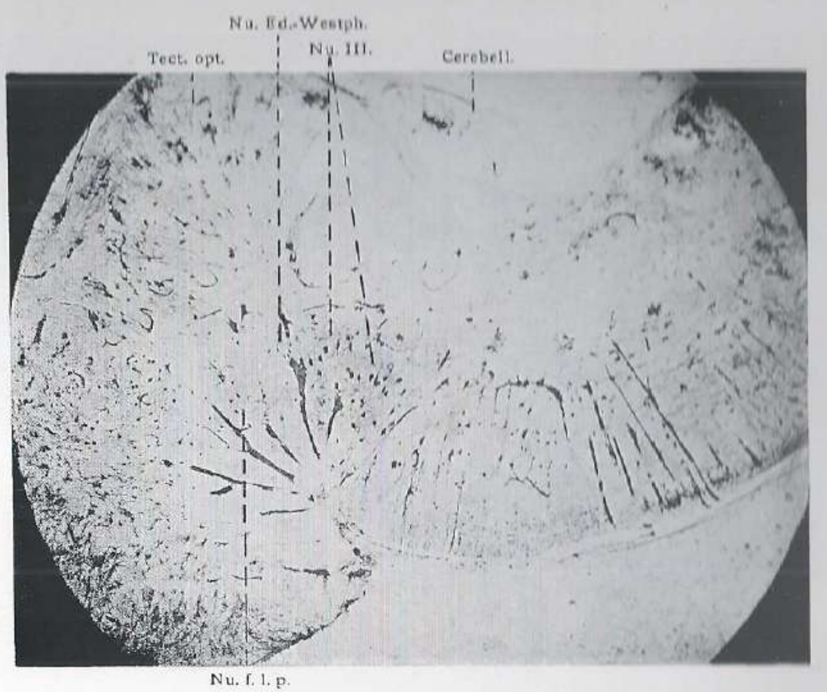

Fig. 63.

Fig. 63 is a microphotograph of a sagittal section of a preparation of the brain of a lizard treated after Cox. In the field of vision lies the mid-brain (mesencephalon). In it the nucleus of the nervus oculomotorius and before this a large blood-vessel. Dorsofrontally from this vessel several smaller cells: the nucleus of *Edinger-Westphal*, or accessory (parasympatic) oculomotorius nucleus, innervating the inner eyemuscles. Through the nucleus of the oculomotorius some fibres of the fasc. long. post., run arising more frontally in the nucleus of the fasc. long. post. Dorsally from this a small group of scattered cells: the nucleus of the commissura posterior (not labeled).