

Anatomy. — “Some notes upon the finer anatomy of the Brain Stem and Basal Ganglia of *Elephas indicus*”. By Dr. A. PŘECECHTEL, Prague. (Communicated by C. U. ARIËNS KAPPERS).

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Until now the brain of the Elephant has been studied chiefly macroscopically, especially by DEXLER¹⁾, whilst BOLK²⁾ gave us a minute description of the cerebellum. Concerning its fiber relations, only a description of the rhinencephalon has been given (BINDEWALD)³⁾.

Studying the microscopical sections of *Elephas indicus* in the Central Institute for Brainresearch in Amsterdam, I found several relations in the oblongata, midbrain, thalamus, and basal ganglia, that are of great interest and will be briefly recorded. For comparison several other animals were examined in sections, stained in the same way as the elephants brain, viz. after WEIGERT—PAL en VAN GIESON.

In the cervical cord, the relation of the grey and white matter strikes even the naked eye, the white matter being very abundant, the grey matter relatively scanty. This fact is compatible with the observations made by HOVY⁴⁾, on a whole series of mammals, proving that concomitantly with the size of the body the mutual relation of the two substances modifies in favour of the white matter.

In the *posterior horn* the *substantia gelatinosa* (fig. I. s. g.) is well developed as it is also in the nearest relatives of the Elephant, the Ungulates. This is still more striking (fig. 2) in the upper cervical region where the strong descending Vth ends.

The *substantia gelatinosa* is arranged in folds, as is frequently the case with a greater development of receptive grey matter in the central nervous system (KAPPERS)⁵⁾ and equally occurs in the spinal cord of Ungulates (BIACH⁶⁾).

¹⁾ DEXLER. Zur Anatomie des Nervensystems von *Elephas indicus*. Obersteiner's Arbeiten, 1907. Festschrift.

²⁾ L. BOLK. Das Cerebellum der Säugetiere. Bohn, Haarlem, 1906.

³⁾ BINDEWALD. Das Rhinencephalon von *Elephas indicus*. Zoolog. Jahrb. (Anat. und Ontog.) Bnd. 35, 1913.

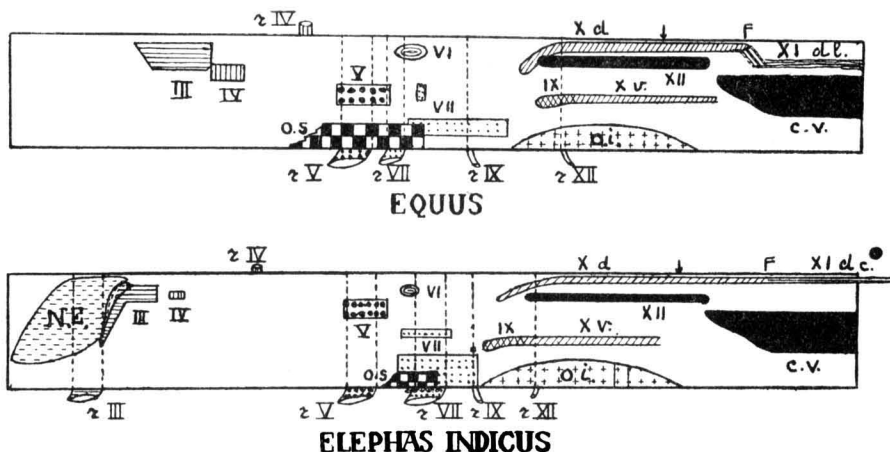
⁴⁾ HOVY. On the relation between the quantity of white and grey substance in the central nervous system. These Proceedings, 16. p. 311.

⁵⁾ ARIËNS KAPPERS. Ueber das Rindenproblem und die Tendenz innerer Hirnteile sich durch Oberflächenvermehrung statt Volumzunahme zu vergrößern. Folia Neurobiologica, Bnd. VIII, No. 4, 1914.

⁶⁾ BIACH Das Rückenmark der Ungulaten. Obersteiner's Arb. Bnd. 16, 1908.

The two posterior funiculi distinctly differ from one another by the thickness of their fibres. The neurones of the medial fascicle (GOLL) are thicker than those of the lateral fascicle (BURDACH). This may be explained by the fact that the medial posterior funicular bundle is longer than the lateral posterior bundle, since JOHNSTON¹⁾ has pointed out that an axon often increases in a cellulo-fugal direction.

Dorsally to the *frontal horns* of the cervical region the *nucleus accessorii* is found lying medially in the central zone between the anterior and posterior horns, its root fibres running laterally in a dorsally concave arch (see fig. 2) and leaving the cord between the anterior and posterior root, but nearer the posterior root.



Diagrams showing the difference in topography of the motor nuclei in the horse (VERMEULEN) and Elephant. The arrow indicates the calamus, the flag the hindpole of the dorsal X nucl.

The cells of the nucleus accessorii are polygonal, and form a dorsal column that is not characterized by an invariably equal thickness, but arranged like a string of beads, reaching much further caudal into the cervical medulla than in any other mammal. In cranial direction this nucleus XI passes almost imperceptibly into the column of cells forming the dorsal nucleus vagi. This long caudal extension of the nucleus accessorii in such a dorso-central position is very rare in mammals. Mostly this part of the accessorius nucleus shows a more lateral location, although these lateral cells — as was demonstrated by VERMEULEN²⁾

¹⁾ JOHNSTON. Additional notes on the cranial nervecomponents of *Petromyzon*. Journ. of Comp. Neurology, Vol. 18, 1908. and "The significance of the caliber of the parts of the neurone, *ibidem*.

²⁾ VERMEULEN. The vagus area in *Camelidae*. These Proceedings 17, p. 1119. and *Die Accessoriusfrage*, Psychiatrische en Neurologische Bladen, 1918.

and KAPPERS¹⁾ may show connections with the central or dorsal vagus group. — According to my opinion this dorso-central XI nucleus innervates the *R. internus* XI that joins the vagus peripherally and is sympathetic in function.

I suppose that it is this same nucleus that in Ungulates keeps its attachment with the dorsal X nucleus but for the main shifts more laterally in the intermediary zone. We know from the researches of BOK²⁾ and POLJAK³⁾, that also in the spinal cord a more central and more lateral sympathetic group exists (which are closely related) in the intermediary zone.

I have not been able to trace the homologue of the ventro-lateral XI nucleus innervating the homologues of the sterno-cleido-mastoideus and trapezius in the sections that were available, although its existence is doubtless on account of the muscles and the big size of the spinal XI root.

At the point of transition of the cervical medulla into the medulla oblongata dorsally to the *canalis centralis*, the *commissura infima* appears, containing o. a. decussating fibres of the *fasciculus solitarius* that terminate on the contra-lateral side in the *commissural nucleus* of CAJAL, which is very conspicuous in this animal.

About the same level, the nuclei of the posterior funiculi are seen, first the more caudally situated nucleus of the funiculus of GOLL and more frontally the nucleus of the funiculus of BURDACH, the grey matter of which shows a characteristic lamellar arrangement especially in its caudal part.

The decussation of the spinal pyramids is small, its bundles bending dorsally and running caudally in the *dorsal* fascicles which is the most primitive course of the dorso-lateral pyramids and also found in some Ungulates and Marsupials.

Very striking in the elephant are the strong *fibrae acuatae externae* (f.a.c. fig. 3) running from the nuclei of GOLL, BURDACH and MONAKOW into the region of the inferior olive (*fibrae praetrigeminales*). KAPPERS supposes them to be connected with the inferior olive either directly or by collaterals. He found them strongly developed in Edentates, Anthro-poids and man (l. c. p. 214, 215, 598). They run from dorso-caudal into a fronto-ventral direction (unlike the olivo-cerebellar tract).

Of the motor oblongata nuclei the facial nucleus (fig. 5) deserves mentioning on account of the close accumulataion of its cells and its distinct division in groups, a

1) ARIËNS KAPPERS. *Vergleichende Anatomie des Nervensystems der Wirbeltiere und des Menschen*, Teil I, 1920.

2) BOK. *Die Entwicklung von Reflexen und Reflexbahnen III. Die Ontogenese des Rückenmarkreflexapparates mit den zentralen Verhältnissen des N. sympathicus*. Psych. en Neurol. Bladen 1922.

3) POLJAK. *Ueber die Intermediärzone im Rückenmark der Säuger und ihr Verhältnis zum vegetativen Nervensystem*. Liječnički Vjesnik (Zagreb, 1924).

phenomenon which probably is connected with the fact that this nucleus innervates the fine stereopractic organ of this animal, the proboscis, whose sensory innervation is largely the trigeminus against whose descending tract the nucleus is located, being bordered on the medial side by the superior olive which may elaborate auditory reflexes on the external and internal ear muscles (M. Stapedius). A dorsal facial nucleus lies above the frontal half of the main nucleus. The VII nucleus receives many pyramidal fibres.

The arrangement of the XII nucleus resembles closely the one described by STUURMAN¹⁾ in the mouse. The nuclei of Roller are very distinct. (fig. 5). The vagus nuclei are well developed, specially the dorsal nucleus, as is generally the case with herbivora, and probably has to be explained by the large stomach of these animals (VERMEULEN l.c.).

Apart from a (rather small) abducens nucleus there seems to be an accessory VI nucl. as described by TERNI²⁾ in rodents, lying near the descending Vth tract.

The motor Vth nucleus is relatively small as usually in herbivora, the largest motor V nucleus occurring in carnivora, whose jaw musculature is much more developed (KAPPERS l.c.).

The system of the Nervus VIII and the cerebellar connections show many primitive peculiarities.

The *nucleus ventralis nervi octavi*, situated ventrolaterally to the corpus restiforme, is not very large and has not shifted as far ventrally as f. i. in Chiroptera and in Carnivora, where the cochlear root is relatively much thicker.

Dorso-medially from the corpus restiforme there even is a cluster of oval cells of the same shape and size as the nucleus ventralis, and which may form a part of the ventral nucleus that — as in *Didelphys* (STOKES³⁾) — has remained in its original position.

Also the *tuberculum acusticum* is little developed and the same may be said of the *oliva superior* (fig. 6, o. s.) nearly entirely situated on the level of the nucleus nervi facialis, medially to it.

Frontally the olive can be traced a little farther than the frontal pole of the nervus facialis, but it gradually disappears in the reticular substance. The relatively small dimensions of the oliva superior are striking but the situation of the facial nucleus so near to it suggests that its reflectory relation with the facial muscles (of the ear) is very close.

The *system n. vestibularis*: The chief vestibular nucleus, the *nucleus of Deiters* with its characteristic large polygonal cells is very strong in the elephant and caudally passes into a large *nucleus vestibularis descendens* (fig. 4), terminating with the *nucleus of Blumenbach* or *Monakow*, which appears as a latero-anterior segment of the *nucleus of Burdach*.

From the Deitersnucleus and the descending VIII cells one plainly sees the fibres of the tractus Deiterospinalis running ventromedially.

The *nucleus triangularis*, medially to the nucleus of DEITERS, consist-

¹⁾ STUURMAN. Die Lokalisation der Zungenmuskeln im Nucl. hypoglossi. Anat. Anzeiger, Bnd. 48.

²⁾ TERNI. Ricerche sul nervo abducente ed in special modo intorno al significato del suo nucleo accessorio d'origine. Folia Neurobiologica, Vol. XII, 1922.

³⁾ STOKES. The acoustic complex and its relations in the brain of the opossum (*Didelphys virgiana*). American Journ. of Anatomy, Vol. 17, 1912.

ing of small cellular elements, is situated quite dorsally under the base of IV-ventricle. Its area is well marked, particularly in caudal levels (fig. 4 X) where it lies medially near the tractus vestibularis descendens and its nucleus, extending caudally a little farther than the commencement of the frontal pole of the nucl. hypoglossi. Here medially from it the tractus solitarius is seen with its grey substance (nucleus parasolitarius) laterally attaching to it.

The nucleus of BECHTEREW lies in the frontal continuation of Deiters nucleus at its typical place near the angle of the ventricle (fig. 5. nu. Bech.). This nucleus consists of cellgroups from which cellular strands run into the cerebellum in a frontal concave arch.

It is possible to trace a direct continuation of this nucleus as far as the medial cerebellar nucleus (nucleus tecti, fig. 5), from which it is obvious that evolutionally the two structures are associated, and that the grey matter of the oblongata has immigrated into the cerebellum (KAPPERS, VAN HOEVELL). To all appearance vestibular fibres ascend to the cerebellum along this strip of grey matter (as has been also described by VAN GEHUCHTEN). Almost completely — but not entirely — separated from the nucleus medialis or the nucleus tecti is the nucleus dentatus (nu. dent.), that is not connected either with the nucleus of BECHTEREW.

Dorsally the dentate nucleus is split, its upper part being situated more dorsally and medially, the other part being situated more ventrally and somewhat laterally.

Frontally the nucleus tecti (of which we know that it is chiefly connected with the anterior lobe of the cerebellum) extends farther than the n. dentatus.

The afferent *connections of the cerebellum* are extremely large, especially the brachium pontis (fig. 6) and the corpus restiforme (fig. 4). In these tracts there are deposits of grey substance that we may designate as the *nuclei brachii pontis* and *nuclei corporis restiformis*. If we trace the sections of the oblongata from the caudal segments, the corpus restiforme, containing reticularly arranged grey matter, begins to appear in the same sections as the posterior pole of the oliva inferior. Frontally the grey substance of the corpus restiforme increases, extending ventral laterally to the tractus trigemini descendens. Dorsally it extends to the nucleus of the descending VIII (see fig. 4). The most external layer of the corpus restiforme does not contain this grey matter. The more frontally, the more the grey matter increases and at the same time extends in strips as far as the ventral pole of the radix trigemini descendens, and occasionally as far as adjacent olive, viz. in those sections in which the tract from the olive inferior attains its greatest volume. More frontally imbedded grey substance diminishes again in the corpus restiforme until it is completely lost on the level of the frontal pole of the inferior olive. Here only from the nucleus DEITERS, i.e. from the frontal conti-

uation of the nucleus of the descending vestibularis, a short strip of grey matter extends between the trigeminus descendens and corpus restiforme.

In more proximal sections, strips of another grey substance appear in the *brachia pontis*, connecting the region of the nucleus DEITERS and its proximal continuation (the nucleus BECHTEREW) with the nuclei pontis. Since (as has already been stated above) the nucleus BECHTEREW is also contiguous with the strips of grey matter extending to the nucleus medialis cerebelli (n. tecti) it results from this that in the elephant there is a bridge of grey matter extending from the nucleus medialis cerebelli to the nuclei of the pons (fig. 5, 6: nu. br. pon.). The distribution of grey matter in the brachium conjunctivum pontis reaches even the most frontal segments of the pons. This appearance of grey matter testifying to the relation of the vestibular area both with the nuclei pontis in frontal and with the corpus restiforme and even with the oliva inferior in caudal direction, is not a regular phenomenon in adult mammals. It may however be well explained by the ontogenetic development of these structures. In 1907 ESSICK has described in man the so-called *corpus pontobulbare*. This is a strip of fibres accompanied by groups of cells and extending from the dorso-lateral somatosensitive static area in a ventromedial direction between the root of the acusticus and facialis, ventrally and frontally. ESSICK²⁾, confirming the work of HIS¹⁾, has demonstrated in human embryos as well as in guinea-pig and rabbit embryos the genetical association of the oliva inferior (and nuclei arcuati) and the nuclei pontis with the static area of the bulb, just behind the cerebellum. The corpus ponto-bulbare of ESSICK indicates the path followed by the descending grey matter of this area to the pons. In our sections it is possible to see the relation between the nucleus DEITERS and BECHTEREW and the nuclei pontis, which may be neuro-biotactically understood by the collaboration of the pontine and vestibular apparatus in cerebellar function²⁾.

In the elephant however it is possible to ascertain also the connection of the area statica with the oliva inferior by the grey matter in the corpus restiforme which is exactly co-extensive with the length of the oliva inferior. Also this (fig. 4) may be explained by the embryological work done by HIS and ESSICK and confirmed by KOOY³⁾ concerning the origin of many cells of the inferior olive from this area which again may be explained by the functional relation between these structures.

1) HIS. Ueber die Entwicklung des Riechlappens und des Riechganglions und über die des verlängerten Marks. Verhandl. der anat. Gesellschaft, Berlin, 1889.

2) ESSICK. The corpus ponto-bulbare, a hitherto not described nucleus in the human brain. Journ. of Anat. Vol. 7, 1907.

ESSICK. The development of the nuclei pontis and the nucleus arcuatus in man. Journ. of Anat., Vol. 13, 1912.

3) KOOY. The oliva inferior. Folia Neurobiologica, Bnd. 10, 1916. In this paper also an accurate description of the oliva inferior in the adult elephant is found.

In man a small island of grey matter is found constantly in the corpus réstiforme, as ascertained by HIROSE¹⁾ in 1920 (in 13 investigated cases). This nucleus in man is however very small, its long axis measuring 0,5—0,3 mm. in length. Its deposition is constant.

As the nucleus is situated on a level where the oliva inferior is most developed, its relation to the above mentioned structures is probable.

In no adult animal these genetical alliances between the area statica on one hand and the pons and inferior olive on the other are so clear as in the elephant.

The pons grey is very conspicuous. It is distinctly to be seen that the *fibrae frontopontinae*, situated in the pes pedunculi medially to the pyramid, bend down into the pons before the *fibrae temperopontinae*. They seem to end sooner²⁾. The *fibrae temperopontinae* extend a little further caudally before immersing into the pontine cellgroups which, by a strip of grey matter, are connected with the substantia nigra of the midbrain (fig. 7). On the lateral periphery of the isthmus region, two fascicles are striking: the spino-tectal tract (tr. sp. t.) and dorsally to it the ventral spinocerebellar tract (tr. sp. c. v.). More dorso-medially the large *brachia conjunctiva* are seen (comp. fig. 7: br. conj.).

The midbrain.

The *nucleus ruber*, is rather primitive in structure, the majority of its cells being very large magnocellular elements as far the frontal pole. The extension of the nucleus frontally to the emergence of the oculomotor nerve in the elephant is analogous to its relation in Ungulates (goat), as described by v. MONAKOW³⁾.

Laterally to it part of the fibres of the *brachia conjunctiva* extend farther on and can be frontally traced as far as the thalamus, although it is impossible to determine accurately to which nucleus they run. HORSLEY and CLARKE⁴⁾ assume that this fascicle terminates at least partly in the lateral segment of the thalamus, which may be true also here.

The *substantia nigra* of the pes pedunculi is particularly developed in

¹⁾ HIROSE. A nucleus in the human restiform body. Journ. of the Okayama Medical Association. 1920.

²⁾ This seems to be in favor of the opinion of MASUDA and BOROWIECKI that the fronto-pontine fibres end in cellgroups situated in front of the cellgroups in which the tempero-pontine tract ends.

SPITZER and KARPLUS hold the opposite opinion (c.f. KAPPERS, l.c. sec. p. 733).

³⁾ v. MONAKOW. Der rote Kern, die Haube und die Regio hypothalamica bei einigen Säugetieren und beim Menschen. Arbeiten aus dem neurologischen Institut der Universität Zürich, 1909.

⁴⁾ HORSLEY and CLARKE. On the intrinsic fibres of the cerebellum, its nuclei and its efferent tracts. Brain, 1905.

HORSLEY and CLARKE. Structure and functions of the cerebellum examined by a new method. Brain, 1908.

the median angle of the pes pedunculi (the part called by WINKLER and POTTER ¹⁾ nucl. propius pedunculi). Caudally it is continuous with the grey matter of the pons ²⁾ which is an evidence of their related function. Frontally it may be followed as far as the globus pallidus, thus proving its relationship to the so called ento- and juxta-peduncular nuclei of reptilia and amphibia. The pes pedunculi in the elephant is also very large in vertical direction and even forces the geniculatum mediale considerably upwards. So it appears that the extrapyramidal motor system is very large in this animal.

Of the *nucl. oculomotorius* in the most caudal sections only the dorso-lateral group is seen, as usually. A little more frontally accedes the ventromedial group.

Frontally the two groups of the nucleus fuse and the nucleus acquires a round form in more frontal sections. About the centre — a little more caudally — appears a new group of cells less intensively coloured, and extending as far as the frontal pole of the nucl. oculomotorii. From this topography we must conclude that this group represents the nucleus *Edinger-Westphal*, serving, according to BROUWER ³⁾ a. o., for the innervation of the intraocular muscles.

At its frontal pole the nucleus inclines ventrally and above it begins to appear the large *nucleus ellipticus* which I shall describe in detail further on, together with the hypothalamus with which it is connected (see below). A real central *nucleus Perlia* is not present (it also fails in Ungulates).

The nucleus trochlearis is more primitive than in the horse, lying dorsally, on some distance from the nucleus oculomotorius. It is small and sends its root fibres in the typical way around the aquaeductus Sylvii. Ventrally and close to this nucleus runs the fasciculus longitudinalis posterior. Laterally to this nucleus, a small group of cells is found. This may be a reticular nucleus, as often occurs in this region.

In the mid-brain roof on either side of the aquaeductus Sylvii there are rows of large vesicular cells (fig. 8) that are so large that they can be seen with a moderate loupe. They are the cells of the nucleus of the *mesencephalic trigeminus* from which sensory fibers of the masticatory muscles originate (WILLEMS ⁴⁾). The frontal boundary of these cells coincides with the transverse level on which the frontal boundary of the

¹⁾ WINKLER and POTTER. An anatomical guide to experimental researches on the cats brain (plate XV). Versluys, Amsterdam, 1914.

²⁾ An analogous condition seems to exist in the rabbit if we look at Plate XXI of WINKLER and POTTER'S Anatomical guide to experimental researches on the rabbits brain. Versluys, Amsterdam, 1911.

³⁾ BROUWER. Klinisch-anatomische Untersuchungen über den Oculomotorius Kern. Zeitschrift f. d. gesamte Neurologie und Psychiatrie, 1917.

⁴⁾ WILLEMS. Localisation motrice et kinesthésique. Les noyaux masticateur et mesencéphalique du trijumeau chez le lapin. Névrose, 1911.

oculomotor root is seen and caudally they can be traced even beyond the level of the nucleus nerv. trochlearis. Their considerable size may be explained by the size of the body, as has been shown by G. LEVI ¹⁾ (for the spinal ganglion cells) and by OBERSTEINER ²⁾ (for the Purkyně cells). It is very striking to see each cell nearly always seated in a capillary bifurcation. With some cells it seems that the capillaries enter the cell as has been observed with the intra- and supramedullary ganglion cells in *Lophius piscatorius* by STUDNIČKA ³⁾.

Behind the tectum, in the lateral lemniscus, that can be well traced from the corpus trapezoides, exactly on the level of the issuing point of the root of the trochlearis there is a well developed nucleus of large cells, the position of which (as in the rabbit) corresponds with the ganglion isthmi (fig. 7 g. i.) of Reptilia. Besides there is a well developed geniculatum mediale (fig. 9 g. m.) which may contain the chief part of the g. isthmi of lower vertebrates, the above named nucleus ⁴⁾ being the only part of this ganglion that has kept the original place on the level of the trochlear root, the part included in the ganglion geniculatum mediale having shifted in a frontal direction.

Diencephalon.

The *geniculatum mediale* commences as a lateral prominence (see fig. 10), a little frontally to the posterior pole of the nucleus ruber. This structure is strongly developed in the elephant, although the cochlear system (see above) is rather small, thus giving a new proof that this ganglion has still other functions than cochlear, viz. being connected with spino-mesencephalic fibres (WALLENBERG ⁵⁾). Frontally the geniculatum mediale leaves the periphery extending in the central grey matter medially to the g. geniculatum laterale in the way as described by INGVAR ⁶⁾ approaching the ventral thalamic nuclei. Under it extends a horizontal transverse layer of grey matter lying on the pes pedunculi. This grey substance which I shall call the *nucleus transversus infrageniculatus*, probably

¹⁾ G. LEVI. I ganglii cerebro-spinali. Supplemento al volume VII dell' Archivio italiano di anatomia e di embriologia, 1908.

²⁾ OBERSTEINER. Bemerkung zur Bedeutung der wechselnden Größe von Nervenzellen. Volume giubilare in onore di L. Bianchi, Catania, 1913.

³⁾ STUDNIČKA. Ueber die pericellulären und endocellulären Blutcapillaren der Riesenzellen von *Lophius piscatorius*. K.K. Gesellschaft der Wissenschaften. Sitzungsberichte der mathematisch-naturwiss. Classe, 1903.

⁴⁾ This nucleus is commonly called in mammalian brain anatomy nucl. lemnisci lateralis posterioris; c.f. WINKLER and POTTER: An anatomical guide to experimental researches on the cats brain, plate XXI (Versluys, Amsterdam, 1914) and MARBURG's Atlas des menschlichen Zentralnervensystems (Fig. 32) Deuticke, Wien 1910.

⁵⁾ See the general discussion in his paper: Beiträge zur Kenntnis des Gehirns der Teleostier und Selachier. Anat. Anzeiger, Bnd. 31, 1907.

⁶⁾ INGVAR, On thalamic evolution. (page 700). Acta medica Scand., Vol. 59, 1923

representing WINKLER's and POTTER's¹⁾ c division of the g. geniculatum mediale (fig. 9, 10: nu.tr.i.), extends frontally as far as the geniculatum laterale, a dense layer of fibres separating the structures. Here the nucleus transversus turning in frontal direction laterally and upwards produces a sort of coating for the geniculatum laterale, and finally, extending in front of it, borders the tractus opticus. Some optical fibres pass above this nucleus from which numerous fibres emerge in ventromedial direction. Its function is unknown to me, but its position suggests a relation with the commissura transversa of GUDDEN.

As similar cellgroup occurs in lower fishes, frogs and reptilia.

From the ganglion habenulae the poorly myelinated fasciculus retroflexus (fig. 11) may be easily traced in ventrocaudal direction passing, close in front of the ventral pole of the nucleus ruber and a little medially to it, to the ganglion interpedunculare. Most of the fibres of the fasciculus retroflexus are devoid of myelin, but on its periphery myelinated fibres occur, thus forming a sort of myelin cover for the entire fascicle, as has been described by KAPPERS in fishes (l.c. Bnd. I, p. 80).

The *nuclei anterior and medialis thalami* underneath the ganglion habenulae are clearly separated from the *lateral* and *ventral nucleus thalami*, and the nuclei medialis thalami of either side are united by a broad *commissura mollis*, in which a distinct *nucleus reuniens* is visible. Frontally the medial nucleus (that cannot be with accuracy separated from the anterior nucleus) extends a little further than the lateral nucleus. A pulvinar (fig. 10 pul.) is present, but relatively small. Ventrally to these nuclei we see the *corpus subthalamicum* from which fascicles of fibres run laterally to the globus pallidus (palaeostriatum) above the pes pedunculi (ansa peduncularis, in the field of *Forel*). It is a circumscribed nucleus, especially so at its medial side (less at its lateral side). Other connections with the striatum are such from the substantia nigra and from the nucleus medialis thalami. The latter connection is distinct along its entire course.

The field of FOREL can be easily distinguished, diminishing caudally where it is more and more replaced by fascicles that near the frontal pole of the nucleus ruber run in a dorsal direction, so that on this level they are longitudinally cut in transverse sections, and are seen passing between the nucleus thalami medialis and lateralis which they separate from one another, and in which to all appearances they enter.

The Hypothalamus and its connections with the oculomotor nucleus.

When describing the oculomotor nucleus, I mentioned that its frontal pole bends in ventral direction. This displacement is caused by a large cellgroup lying in front of the nucleus (diagram and fig. 9—12, nu.e.). This group touches the raphe, and is separated from the cellgroup of

¹⁾ WINKLER and POTTER. An anatomical guide to experimental researches on the rabbits brain, Versluys, Amsterdam, 1911 (plate XIX; text page 2).

the other side only by a narrow raphe of grey matter and nerve fibres. Frontally it reaches as far as the thalamus, extending with its frontal pole under the posterior segment of the nucleus medialis thalami. It is ovoid in form, its longitudinal axis running obliquely from behind and above in frontoventral direction. Its transverse form is flattened. Its caudal and central segment come very near the aquaeductus Sylvii and where the nucleus attains its greatest volume, its upper boundary lies close under the aquaeduct of Sylvius, whilst ventrally it reaches as far as the fornix. Ventrolaterally it passes into the central grey matter. In its frontal fourth we may discriminate in it two divisions, a medial and a lateral one that again fuse at the frontal pole. The cells of this nucleus are small and oval.

In front of it and more ventrally the small c. mammillare is found. The fornix is clearly seen, sending fibres to the corpus mammillare without however completely exhausting itself. On the contrary, the greater part of its intensively staining bundles extend beyond the mammillare reaching the level of the cellgroup described above, even extending beyond its frontal pole running ventromedially to it. These fibres finish in the nucleus ellipticus (see fig. 12: f. f. a.).

Ventrally to this nucleus, commencing with its frontal pole along its entire length, there is a decussation of commissural fibres between the nuclei of the two sides (fig. 12, com.). Other fibres running in the medial plane of the nucleus can be traced in caudal division in the raphe to the nucleus oculomotorius and nucleus EDINGER-WESTPHAL (fig. 11, X).

Fibres from the nucleus, entering the oculomotorius roots cannot be seen (only at the posterior pole this is less certain). It is to be questioned whether or not this particular nucleus may be homologized with any nucleus described until now in other mammals.

PERLIA¹⁾ described a nucleus called by him *nucleus medialis anterior* that according to TSUCHIDA²⁾ is formed by a group of cells assembled in a little oval form with a dorso-lateral longitudinal axis. Its cells by their size and structure remind us of the cells of the nucleus of EDINGER and WESTPHAL. Some authors regard this nucleus as a proximal continuation of the medioventral group of the nucleus EDINGER-WESTPHAL. In the majority of examined cases TSUCHIDA was able to isolate this nucleus fairly well, and he and also KAPPERS consider the original opinion of PERLIA to be correct to the effect that we have to deal with a cellgroup from which no rootfibres originate. So it may be that the nucleus ellipticus is chiefly an enlarged nucl. medialis anterior.

The homologue of our nucleus certainly occurs in the Cetacea where it has been described as *nucleus ellipticus* by HATSCHEK and SCHLESINGER³⁾

¹⁾ PERLIA. Die Anatomie des Oculomotorius beim Menschen. Graefe's Archiv f. Ophthalmologie, Bnd. 35, 1889.

²⁾ TSUCHIDA. Ueber die Ursprungskerne der Augenbewegungsnerven und über die mit diesen in Beziehung stehenden Bahnen. Arbeiten a. d. Hirnanat. Institut in Zürich, 1905.

³⁾ HATSCHEK und SCHLESINGER. Der Hirnstamm des Delphins (*Delphinus delphis*). Arbeiten a. d. Neurolog. Institut der Universität Wien, Bnd. IX, 1902. See also ZWEIG (who saw the same nucleus in *Phocaena*). Jahrb. für Psychiatrie und Neurol. Bnd. 41, 1921.

in the Dolphin. I have also closely examined this nucleus in *Phocaena* and compared its size and its relations to those in the elephant. The only difference is that the nucleus in Cetacea is less flattened in medio-lateral diameter. Moreover in the anosmatic *Phocaena* the fornix is not much developed (and moreover poorly stained in my sections). Hence it was impossible to me to ascertain whether or not fibres of it enter the nucleus ellipticus. On the other hand, however, it was to be seen, also in *Phocaena*, that in the raphe, fibres ascend to the nucleus ellipticus and in *Phocaena* the nuclei of either side are connected by a commissure in exactly the same way as in the Elephant.

It is interesting to note that neither in *Phocaena*, nor in the Elephant it is possible to ascertain a nucleus that would correspond to the nucleus *medialis anterior*, unless it were the *nucl.ellipticus*.

That the midbrainbase acts a large part in the search for food in correlation with olfaction is also demonstrated by the presence of the (olfactory) interpeduncular ganglion in all animals in the base of the midbrain. Its relation with vision is expressed by the occurrence of the optic *nucl. peduncularis transversus*¹⁾ in this region in birds (*nucl. opticus basalis*), rodents and ungulates. *Elephas* now gives another striking example of this function, although I could not demonstrate (as I first expected²⁾) a *nucl. pedunc. transversus* in this animal.

Striatum.

I want to add a few remarks on the *neo-striatum* and *palaeo-striatum* in this animal.

It is easy to discriminate these parts of the basal ganglion. Frontally only the *neo-striatum* is seen, where the nucleus caudatus with its considerably developed frontal pole fuses with the other neostriatal part, the putamen.

Behind this place these segments are separated from each other by the capsula interna but then they fuse once more at the caudal end, where the capsula disappears again. Frontally the *neo-striatum* passes into the nucleus *accumbens septi* as described by E. DE VRIES.³⁾

Medially to the nucleus caudatus on its ventricular side there is a layer of fibres that form a lining of the third ventricle, analogous to the *fasc. fronto-occipitalis*, but more complete, forming a thin *capsula intima* (fig. 13, X).

Ventrally to these ventricular fibres the *taenia semicircularis* runs, lying

¹⁾ The homology between the *nucl. tr. peduncularis transversus* of rodents and ungulates with the ganglion *opticum basale* of birds has been established by KOSAKA and HIRAIWA (Zur Anatomie der Sehnervenbahnen und ihren Zentren, *Folia Neurobiologica*, Bnd. 9, 1915).

²⁾ The *nucl. tr. peduncularis transversus* in which a basal optic bundle ends, is situated between the ganglion *mammillare* and the *substantia nigra* closely to the ganglion *interpedunculare* in Rodents and Ungulates.

³⁾ E. DE VRIES. Das Corpus striatum der Säugetiere. *Anat. Anzeiger*. Bnd. 37, 1910.

A. PŘECECHTEL: "Some notes upon the finer anatomy of the Brain Stem and Basal Ganglia of *Elephas indicus*".

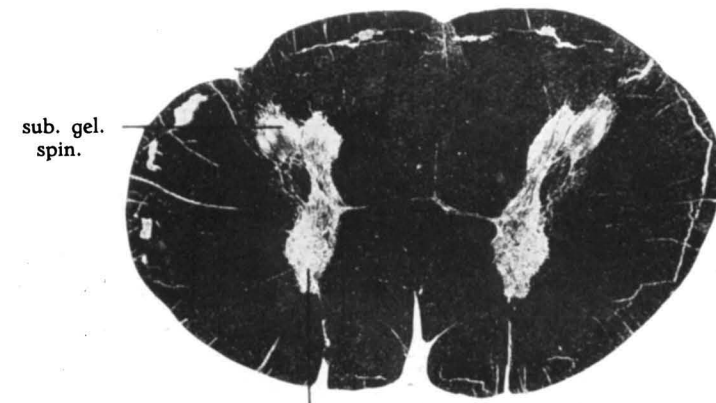


Fig. 1. Cross section of the cervical cord.

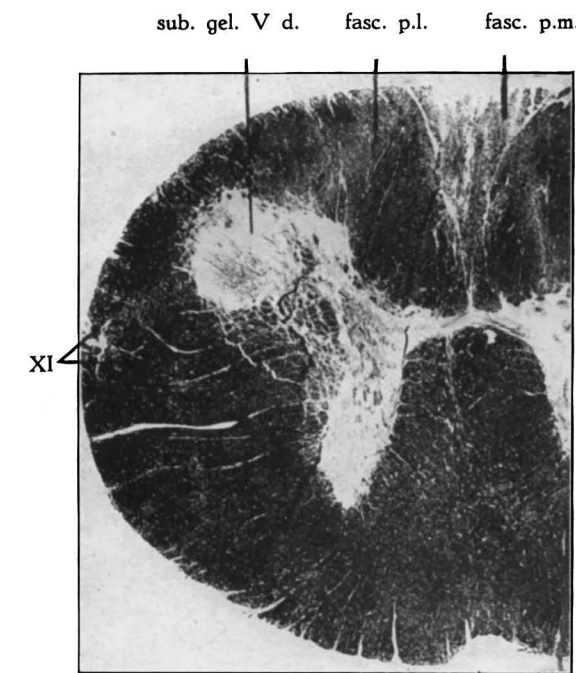


Fig. 2. Cross section of the upper part of the cervical cord.

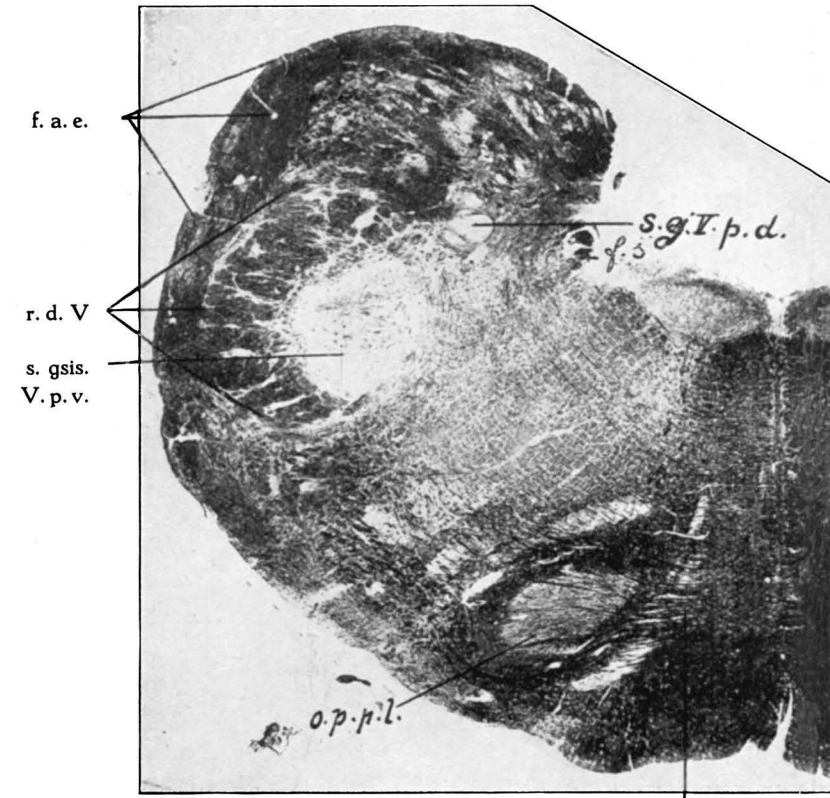


Fig. 3. Section showing the strong development of the fibr. arcuatae externae (f. a. e.) from the nucl. cuneatus externus (Monakow).

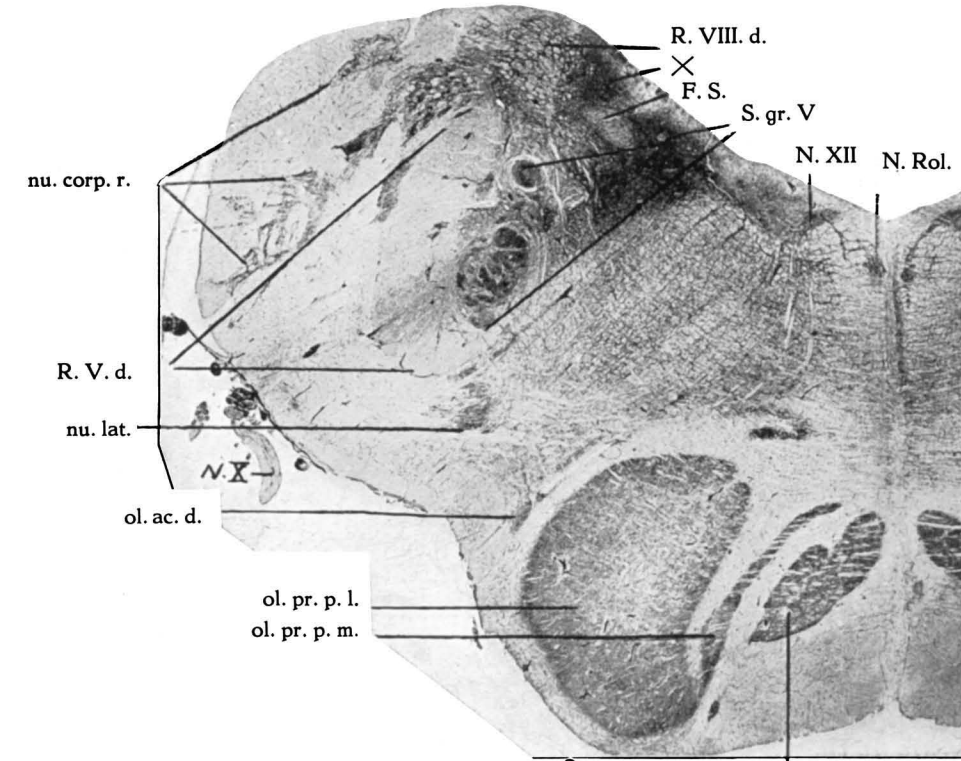


Fig. 4. Section showing the nuclei corporis restiformis (nu. corp. r) and inferior olive.

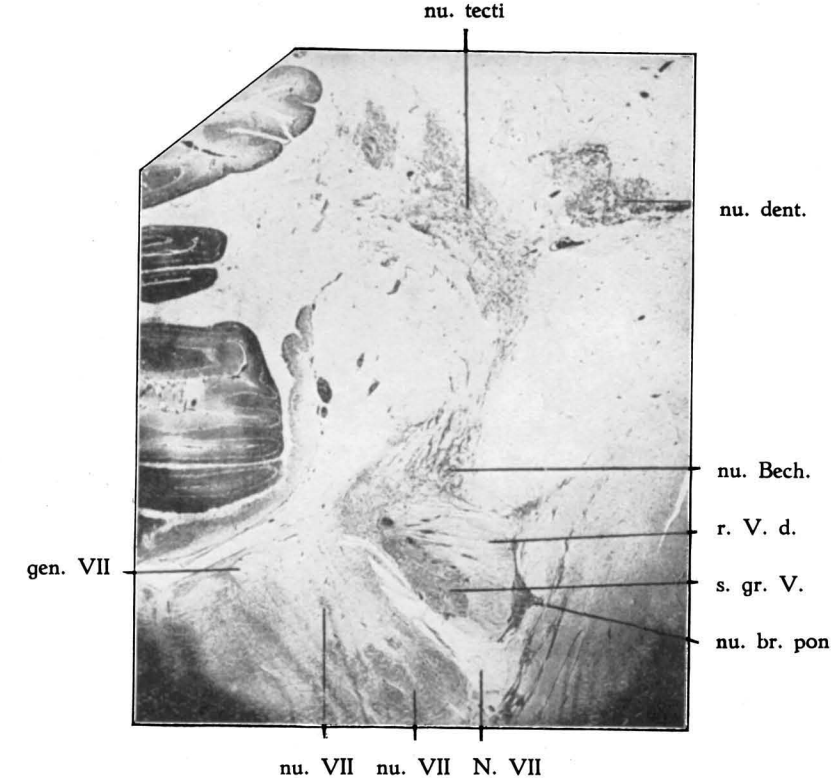


Fig. 5. Nucleus tecti cerebelli and its connection with the nucl. Bechterew. The nucl. brachii pontis and the VII nuclei.

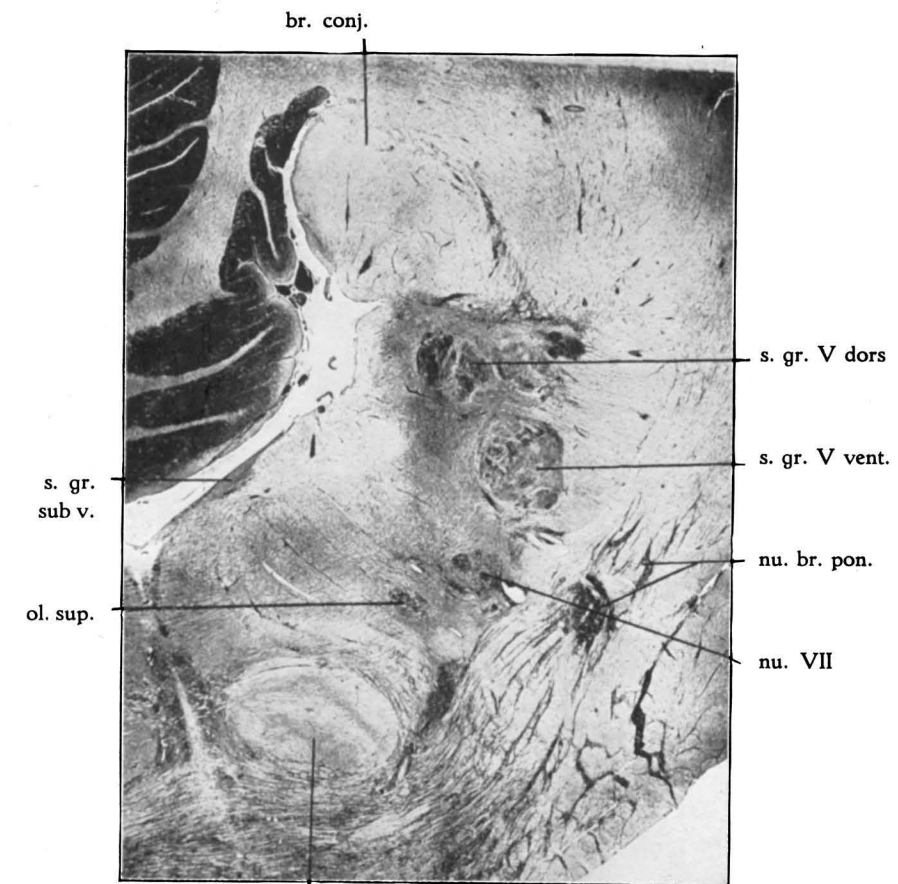


Fig. 6. Showing the nucl. brachii pontis.

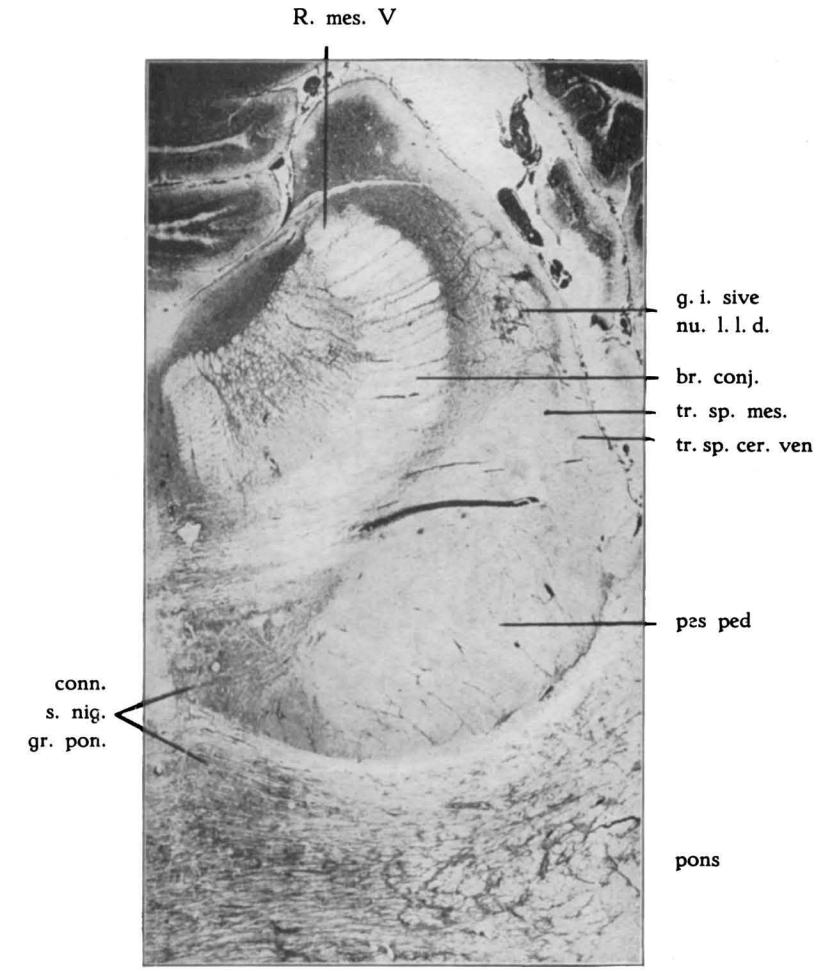


Fig. 7. Showing the connection between the peduncular and pontine nuclei.

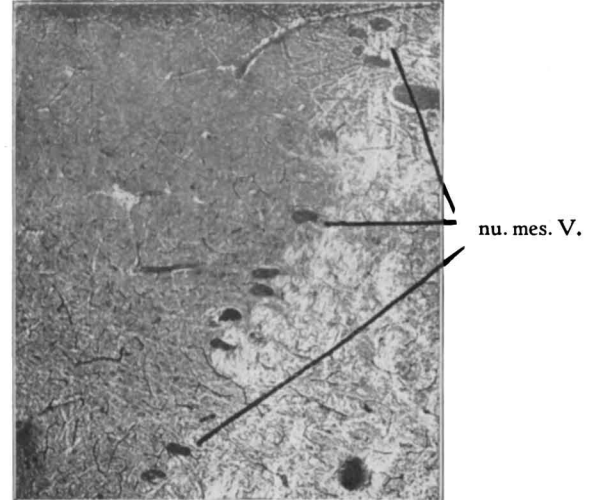


Fig. 8. Nucl. mesencephalicus trigemini. The vascularisation of the cells in seen at the bottom.

A. PŘECECHTEL: "Some notes upon the finer anatomy of the Brain Stem and Basal Ganglia of *Elephas indicus*".



nu. ruber
Fig. 9. The geniculatum mediale with nucl. transversus infrageniculatus.
nu. e. = nucl. ellipticus.

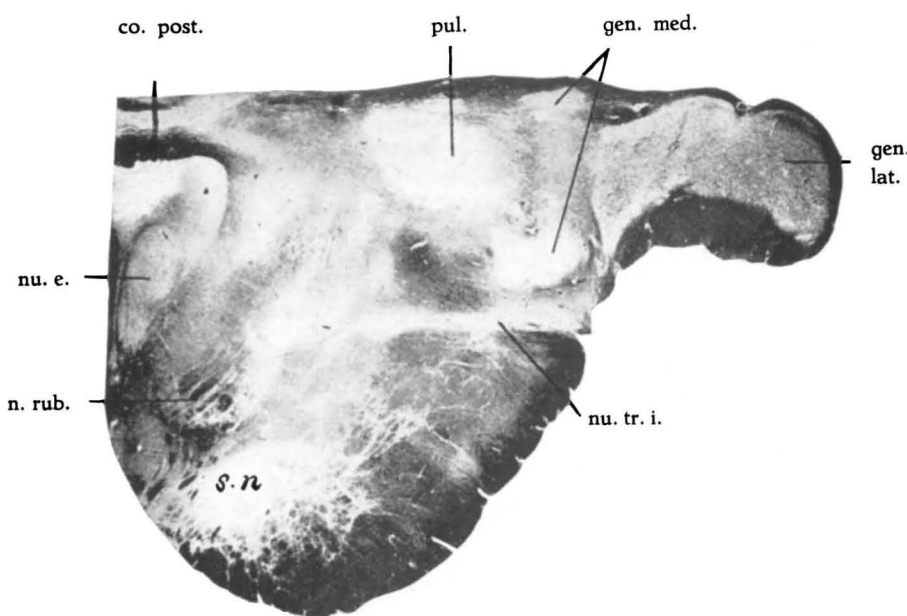
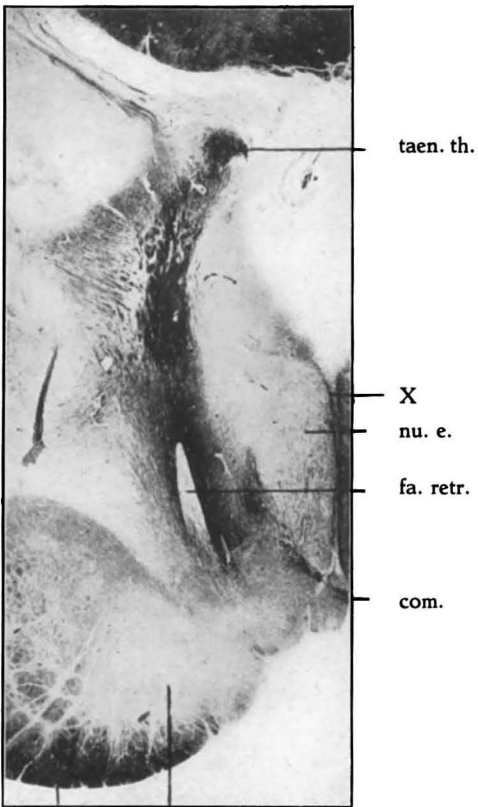


Fig. 10. The nucl. ellipticus (nu.e.); g. geniculata and nucl. transversus infrageniculatus.



pesped. sub. nig.
Fig. 11. Showing the commissural (com.) and ascending fibres (X) of the nucleus ellipticus (nu. e.).

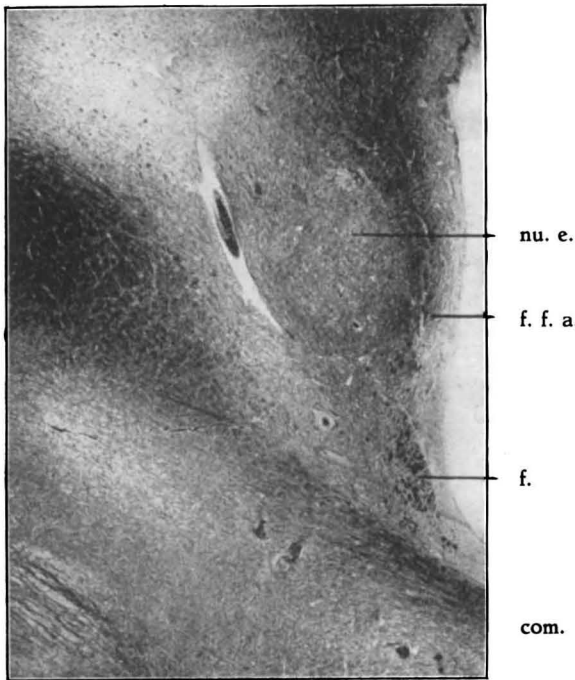


Fig. 12. The fornix (f.) ending with ascending fibers (f. f. a.) in the nucleus ellipticus (nu.e.).

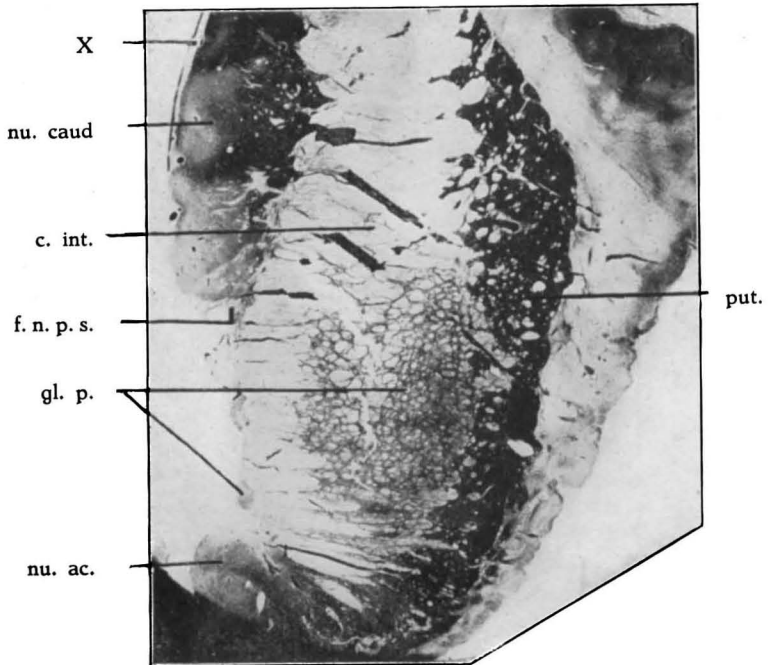


Fig. 13. Showing the subventricular fibers (X) lining the caudate nucleus.
f. n. p. s. = fiss. neo-palaeo striatica. nu. ac. = nucl. accumbens.

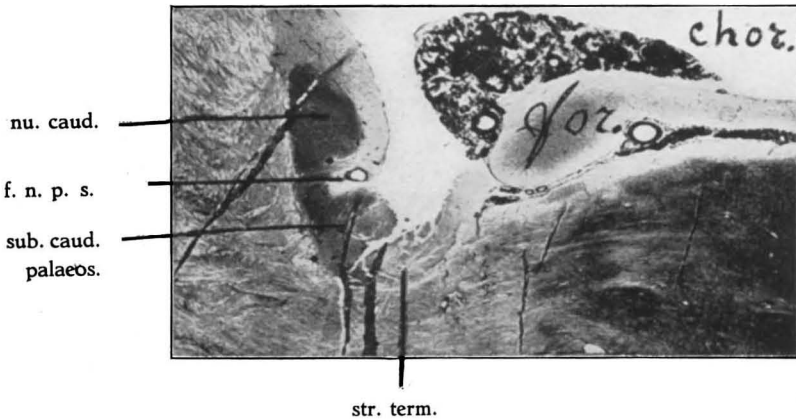


Fig. 14. Cauda nucl. caudati (nu. caud.); fissura neo-palaeostriatica (f. n. p. s.) and substantia palaeostriatica caudata. For. = fornix.

ventromedially against the palaeo-striatum. Originating from the regio parolfactoria and running medially to the striatum the taenia semicircularis can be followed as far as the archistriatum or amygdala as in all other mammals, forming the stria terminalis (fig. 14).

In the elephant, more distinct than in most mammals we find medio-ventrally to the nucleus caudatus (fig. 13) KAPPERS' *fissura neo-palaeo-striatica*,¹⁾ which clearly runs backward, separating the cauda of the nucleus caudatus from the substantia caudata palaeostratica (fig. 14), the small strip of grey matter extending backward from the globus pallidus or palaeo-striatum.

The relations of this fissure are similar to those, described in other animals and man by KAPPERS, and like there a bloodvessel is found constantly near this fissure. Moreover a medial extension of the lamina medullaris externa — the borderlayer between palaeo- and neo-striatum — is seen on several places near this fissure, also in the Elephant.

The *palaeo-striatum* or *globus pallidus* at its strongest development has the appearance of reticular substance, extending through the capsula interna with small strips to the ventricle. Its relations to the substantia nigra and corpus subthalamicum have been mentioned above. It also takes part in the formation of the nucleus accumbens (fig. 13: nu. ac.).

The claustrum, as described by ERNST DE VRIES²⁾ is divided into small islands, that are contiguous with the cortex.

¹⁾ ARIËNS KAPPERS. The ontogenetic development of the corpus striatum in birds and a comparison with mammals and man. These Proceedings 26, p. 135, 1922, fig. 17). See also Archives Suisses de Neurologie et de Psychiatrie, Vol. XIII, 1923.

²⁾ ERNST DE VRIES. Bemerkungen zur Ontogenie und vergleichenden Anatomie des Claustrums. Fol. Neurobiologica, Bnd. 4, 1910, p. 496.