ON THE ANATOMICAL RELATIONS OF THE NUCLEI OF RECEPTION OF THE COCHLEAR AND VESTIBULAR NERVES.

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Since the investigations of Babinski,[1] v. Bechterew,[2] Bumm,[3] Cramer,[4] Flechsig,[5] Forel,[7] Kirilzew,[9] v. Monakow,[12] Onufrowicz,[13] and Roller,[14] much light has been thrown on the central connections of the cochlear and vestibular nerves by Ramón y Cajal,[4] Held,[8] v. Kölliker,[10] Martin[11] and Sala.[15] The exact topographical relations of these nuclei have, however, so far been only imperfectly described.

The material used in the present study was human tissue and consisted of two superb sets of serial sections, transverse and horizontal, through the medulla of the new-born babe, prepared by Dr. John Hewetson at the Anatomical Laboratory of the University of Leipzig. Through the courtesy of Dr. Hewetson these preparations have been made accessible for study to research-workers in the Anatomical Laboratory of the Johns Hopkins University.

A flat reconstruction on millimetre paper has been made from the right-hand side of the sections of the transverse series which show the nuclei in question. Reference to the diagram (Fig. 1) will show the following points: At the lower end of the diagram the zero point on the scale represents the superior (anterior) limit of the decussation of the pyramids, and at the upper end the diagram extends nearly to the lower border of the inferior colliculus of the corpora quadrigemina. The lines drawn across the diagram represent approximately the planes of the sections having the corresponding numbers.* The areas occupied by the nuclei of the nervus hypoglossus and nervus abducens are given to help in orientation. The lines *a–a* represent the lateral boundary of the fourth ventricle, which has been traced from the point at which the canalis centralis opens out into the floor of the ventricle, through the area of the recessus lateralis and forwards to the aqueductus cerebri. The line *b–b* represents the lateral boundary of the corpus restiforme. The entrance of the corpus restiforme into the cerebellum is not shown, but the line runs to its upper limit. The motor and sensory nuclei of the nervus trigeminus are shown with the exception of the nuclei minores (radicis descendentis). The tractus spinalis nervi trigemini, together with the adjacent substantia gelatinosa, is represented in outline from its beginning, at the entry zone of the nerve, downward as far as the decussation of the pyramids. Its course further spinalwards is not given. The entering root bundle of the nervus trigeminus is also not illustrated, but the lowest section which shows it corresponds to number 45 on the scale, and as the nuclei of the nerve are inferior to the point where it enters, the fibres can be traced farther upwards than the diagram goes. The lines d_3 and d_4 represent the surface markings on the floor of the fourth ventricle corresponding to the ala cinerea. The complete length of the nucleus alæ cinereæ is not shown, but it can be traced from the inferior end of the nucleus nervi hypoglossi to the point marked d_1 on the diagram. The line d_1–d_2, in which the two sulci meet, corresponds to the portion of the ala cinerea which has been pushed into the depth by the spreading of the nucleus nervi vestibularis medialis dorsal to it over the floor of the ventricle.

The line *e* represents the continuation of the lateral sulcus over the area occupied by the nucleus nervi abducentis. The sulcus is here further lateral, corresponding to the position of the nucleus nervi abducentis, which is further from the median line than the nucleus nervi hypoglossi.

Nervus vestibuli. The area of entrance of the root bundle of the vestibular nerve is shown in the diagram. The well known fact that the vestibular root bundle is farther forwards (cerebralwards) than the cochlear root bundle is well illustrated. The reconstruction shows clearly the generally recognized fact that the four principal vestibular nuclei are continuous with one another. (See *M.*, *L.*, *S.*, and *R. d. n. ve.* in the diagram.) These nuclei can be distinguished in part by position and in part by the character of the cells within them. The relation of the nucleus nervi vestibularis medialis to the nucleus of the descending tract of the vestibular nerve is very striking. Ramón y Cajal has already pointed out their close connection. The lowest sections in which descending vestibular fibres can be distinctly made out show cells between the fibres (sections between 15 and 17 on the scale). These cells higher up make an oval mass which lies

*The planes of the sections are in reality slightly different from those represented by the lines on the diagram, which are drawn at right angles to the median line. The sections have been cut slightly obliquely, the right side being struck at a higher plane than the left. The slight discrepancies between the drawings of the sections and the diagrams are thus explained.

lateral to the ala cinerea and extends dorsal and medial to the descending vestibular fibres. As the ala cinerea recedes into the depth, and the nucleus nervi hypoglossi disappears, these cells spread to very near the middle line. The large area *M*, together with the dark area *Y*, represents the nucleus nervi vestibularis medialis; it can easily be seen that any division between this nucleus and the nucleus of the descending vestibular tract, throughout their whole extent, must be merely an arbitrary one. It is extremely difficult, too, to determine exactly the medial border of the nucleus nervi vestibuli medialis; it goes over insensibly into the central gray matter surrounding the ventricle. In general the nucleus nervi vestibularis medialis begins from 2½ to 3 mm. below the superior end of the nucleus nervi hypoglossi and extends in the floor of the fourth ventricle as far forward as the nucleus nervi abducentis. Its anterior extremity (*Y* in the diagram) passes forward some distance further lateral to the nucleus of the sixth nerve. The descending tract of the nervus vestibuli begins at the entry zone of the vestibular root fibres in the region of the nucleus nervi vestibularis superior (Bechterew), and of the nucleus nervi vestibularis lateralis (Deiters). It is made up of the descending branches of the root fibres and lies dorsal to the tractus spinalis nervi trigemini, at first at a distance of 1.3 mm. from the floor of the ventricle (Fig. 3). Farther posterior it approaches the floor, and the isolated bundles of fibres of which it is made up occupy a very characteristic oval area, the long diameter of which lies in the dorso-ventral direction (Fig. 2). A reference to the diagram will show that it extends downward from its origin in a straight line as far as the level of the superior (anterior) end of the nucleus nervi hypoglossi. From this point it curves medialwards, giving place to the nucleus funiculi cuneati. It can be traced downwards to a plane a little superior to the middle of the nucleus nervi hypoglossi. The ascending branches of the vestibular fibres are not represented in the diagram, but they are shown in figs. 3 and 4.*

At the extreme superior and lateral angle of the nucleus nervi vestibularis medialis is situated a large group of cells, in part capping the descending tract of the vestibular nerve (Fig. 3, *Nu. y*). It is oval in shape and is distinctly visible in section just below the floor of the fourth ventricle. As will be seen in the diagram (Fig. 1, *Y*), it lies adjacent to the nucleus nervi vestibularis lateralis, to the nucleus nervi vestibularis medialis, and to the nucleus nervi vestibularis spinalis (Radix descendens). This nucleus, however, is worthy of a special description in that it is peculiar: (1) in the size of the cells, they being much larger than those of that part of the nucleus nervi vestibularis medialis marked *M* in the diagram, but smaller than those of the nucleus nervi vestibularis lateralis; (2) by the staining capacity of the mass, which on the whole stains in Weigert-Pal preparations of the new-born babe much darker than Deiters' nucleus of the same section; (3) by the fact that the cells are closely packed together, which brings it into marked contrast with the more scattered cells of the nucleus nervi vestibularis lateralis; (4) by its distinct outline in *well stained* preparations, which makes this group of cells easier to differentiate than any of the other vestibular nuclei. A reference to Figs. 3 and 4, and to the diagram, Fig. 1, will show the position of the nucleus. This nucleus evidently corresponds to a part of the *ganglion dorsale acustici* of v. Kölliker (*Hauptkern* of Schwalbe.) It is continuous posteriorly with the nucleus of the descending root, and laterally (in its posterior part) with the rest of the nucleus nervi vestibuli medialis. It is not so easy to locate it definitely in series in which the gray masses are not particularly well differentiated, but even in such a series, after having defined it easily in Dr. Hewetson's sections, its limits have been recognized without much difficulty. Until attention can be paid to the course of the axones of these cells and a comparison can be instituted between its constituent neurones and those of the other vestibular nuclei, I prefer to give the group a distinct place in the diagram and to refer to it as nucleus *y*.

It may further be seen in the diagram that the nucleus nervi vestibularis lateralis and the nucleus nervi vestibularis superior are in the region of the entry zone of the vestibular nerve. The lateral nucleus appears to be separated into two portions by the root fibres of the nerve. One part (L_1 in Fig. 1, and *Nu. n. v. l*, in Fig. 3) is further inferior (posterior) and lateral, and it lies also further ventral than the other part (*L* in Fig. 1, and *Nu. n. v. l* in Fig. 4). L_1 lies between the entry zone of the vestibular root fibres and the corpus restiforme. Its cells are rather smaller than those of *L*. The part of Deiters' nucleus marked *L* lies in its upper part almost in the floor of the fourth ventricle and is continuous laterally with Bechterew's nucleus, from which it can be easily distinguished, however, by the size of the cells. In the longitudinal series these two parts of Deiters' nuclei *L* and L_1 are seen to be in reality continuous; a few scattered cells joining them can be seen between the fibres of the nerve. They are seen with the high power not to be such separate entities as the diagram would make them appear. In his articles on the medulla oblongata Ramón y Cajal describes the nucleus nervi vestibularis lateralis in the white mouse as a crescent-shaped mass, convex on its dorsal border, and showing two sorts of cells, the larger being further ventral, the smaller more dorsal and lateral. In human tissue I find that the nucleus is convex on the ventral border, and to be so inclined that on the whole the smaller cells are further ventral as well as lateral. Fig. 3 shows the lateral portion (L_1) of the nucleus nervi vestibularis lateralis, while Fig. 4, which represents a section .6 mm. further forward, shows the medial portion (*L*).

The nucleus nervi vestibularis superior (Bechterew) lies in the floor and lateral wall of the fourth ventricle, occupying its lateral angle. In the diagram, Fig. 1, it is marked *S* and is given a heavy outline. It lies in a plane dorsal to that of the nucleus nervi vestibularis medialis, and its inferior (posterior) extremity corresponds about to the inferior (posterior) end of Deiters' nucleus. As seen in the diagram

* The so-called cerebellar acoustic nucleus of Ramón y Cajal, the cells of which accompany these fibres, is not represented. No attempt was made to locate in the diagram the gray masses in the roof of the cerebellum, with which the ascending branches of the vestibular nerve undoubtedly come into relation.

it extends even further laterally than does the nucleus nervi vestibularis lateralis of Deiters. A reference to Figs. 3 and 4 will show that it is bounded laterally in a part of its course by the corpus restiforme. As the nucleus extends upwards (cerebralwards) it lies more and more dorsally, so that it comes to lie between the lateral wall of the ventricle and the brachium conjunctivum. It is interesting to note how far it can be traced at its cephalic extremity into the region of the nuclei of the nervus trigeminus. It is traversed by the ascending branches of the root fibres of the vestibular nerve.

There seems to be a general agreement that the root fibres of the vestibular nerve bifurcate. The descending limbs pass into the descending root, many of the ascending go up into the cerebellum. Recent investigations make it probable that axones also run in the opposite direction from the cerebellum to the nucleus nervi vestibularis lateralis. Fig. 4 shows two distinct sets of fibres extending between the cerebellum and Deiters' nucleus; one running between the brachium conjunctivum and the corpus restiforme and lying in the plane of the transverse section for a considerable distance, the other being more medial and going actually through the nucleus nervi vestibularis superior and the brachium conjunctivum. The latter fibres are so inclined that they do not run far in the plane of any one section, but by following the series downward (caudalwards) from the region of Deiters' nucleus, scattered fibres show in the brachium conjunctivum, lying in a plane perpendicular to the fibres of the latter, and so contrasting strongly with them. These fibres are farther dorsal in each succeeding section downward as far as the nucleus fastigii, dorsal to which a well marked decussation is visible (Figs. 3 and 2).

Fig. 5 represents a longitudinal section taken through the area of the vestibular nuclei. The lines 66 on the transverse sections represent approximately the plane of this section. All of the vestibular nuclei, the nucleus nervi vestibularis medialis (with the part of it which I have designated nucleus *Y*), the nucleus of the descending vestibular root, the nucleus nervi vestibularis lateralis and nucleus nervi vestibularis superior, are shown.

Very little of the nucleus nervi vestibularis superior shows, however, inasmuch as this nucleus lies for the most part dorsal to the plane of this section. It will be seen that there is a well marked group of fibres β running obliquely forwards from the region of the nucleus nervi vestibularis superior. These fibres have been traced on both series, and the area they occupy is represented in the general diagram (Fig. 1, *z*). They extend between the nuclei of the nervus trigeminus and the raphe. Toward the floor of the ventricle they pass through the nucleus nervi vestibularis superior, as is shown in the diagram. They decussate in the raphe dorsal to the fasciculus longitudinalis medialis. As to their further course it is impossible to say from these sections.

Nervus Cochleæ. The areas corresponding to the nuclei of the nervus cochleæ are illustrated in Fig. 1. It is interesting to note that the nucleus nervi cochlearis dorsalis is continuous with the nucleus nervi cochlearis ventralis and that the transition from the one to the other is very rapid. Figure 6 represents a reconstruction to show the relations of the cochlear nuclei to the corpus trapezoideum and the complex of the nucleus olivaris superior. The nucleus nervi cochlearis dorsalis begins just above (anterior to) the nucleus nervi hypoglossi. It is in the dorso-ventral direction a long, narrow nucleus, the apparent breadth of the area representing it in the diagram being due to the fact that it curves somewhat around the corpus restiforme. Its size and general character are illustrated in Fig. 2. Both the section and the diagram show how far lateral it lies, though it by no means extends so far lateral as the nucleus nervi cochlearis ventralis, a point which is in disagreement with many of the figures in the text-books. It has comparatively few medullated axones in it, and these run parallel to the long axis of the nucleus as seen in transverse section. The division into three zones, a mesial, middle and lateral, is clearly shown in Fig. 2. This division has already been described by von Kölliker and by Sala. The mesial and lateral zones are rich in medullated fibres.*

In Fig. 6 is represented a flat reconstruction of the mesial and lateral bundles of medullated fibres of the nucleus nervi cochlearis dorsalis. The mesial bundle is marked *m*, and the lateral *l*. It may be seen that the areas corresponding to both bundles run toward the middle line.

The fact that the root bundle of the cochlear nerve enters the nucleus nervi cochlearis ventralis has been observed by Held and Sala. It is interesting to note in Fig. 6 that the area of the entering root bundle of the nervus cochleæ is considerably superior (anterior) to that of the nucleus nervi cochleæ dorsalis. Both Held and von Kölliker have described the bifurcation of the cochlear root fibres. Ramón y Cajal has observed the bifurcation both in the new-born mouse and in the rabbit and says that it takes place in the nucleus nervi cochlearis ventralis.

The two branches are, he states, usually equal in calibre, but the ascending branches are short and end in the nucleus nervi cochlearis ventralis. On the other hand the descending branches are longer and can be traced in a definite bundle to the inferior part of the nucleus nervi cochlearis ventralis and the nucleus nervi cochlearis dorsalis. He says that in the mouse these fibres, at first scattered, soon form a definite bundle, which can be traced to the inferior part of the nucleus nervi cochlearis dorsalis. A bundle of medullated fibres, apparently corresponding to the bundle of axones described by Ramón y Cajal, has been easily traced in the sections I have studied, and is shown in the figure (Fig. 6, *h*). Near the entry zone of the cochlear nerve it consists of scattered fibres, but it soon forms a compact bundle on the mesial border of the ventral nucleus. The bundle runs spinalwards and at the same time so rapidly dorsalwards that in cross section its fibres are cut almost longitudinally. The reconstruction brings out the fact that it is connected with the mesial zone of the nucleus nervi cochlearis dorsalis corresponding to the area of medullated fibres *m* (Fig. 6).

The arrangement of the fibres of the nucleus nervi cochlearis dorsalis in parallel lines has already been mentioned (Fig. 2). In strong contrast to this is the appearance of the nucleus

*According to Sala the cells of the mesial layer and the middle zone give rise to the striæ acusticæ.

nervi cochlearis ventralis (Fig. 3). The arrangement of the cells and fibres of the ventral nucleus in the form of a basket-work has already been described by Held, von Kölliker and Ramón y Cajal. The latter divides the nucleus nervi cochlearis ventralis into two regions, an inferior (tail) and a superior (head). In the human tissue which I have studied it is the inferior part that is characterized by the basketwork. In the superior portion the cells are fewer and more scattered. Indeed, the cells are so scattered and there are so many fibres running to the corpus trapezoideum in this region that it is very difficult to determine exactly in Weigert-Pal preparations the superior limit of the nucleus. The area *C. t.* (Fig. 6) represents the corpus trapezoideum. It may be noticed that the lateral boundary of the corpus trapezoideum is continuous with that of the lemniscus lateralis. In both series of sections a continuous line of cells can be traced from the nucleus olivaris superior to the nucleus of the lemniscus lateralis, so that it is impossible to say where the nucleus of the lemniscus lateralis begins. A description of the auditory neurones of the second order cannot be entered into at this time. The diagram shows very clearly, however, the intimate connection of the nucleus nervi cochlearis ventralis with the corpus trapezoideum and superior olivary complex. An examination of Fig. 2 shows how few fibres are medullated at this period in the nucleus nervi cochlearis dorsalis. They are so scattered after leaving the nucleus that it is very difficult to follow them far. The long distance between the nucleus olivaris superior and the anterior extremity of the dorsal cochlear nucleus is another striking feature of the diagram.

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Bibliography.

1. Baginski: Ueber den Ursprung und den centralen Verlauf des Nervus acusticus des Kaninchens. Virchow's Archiv, Bd. 105, H. 1, S. 28.—Ueber den Ursprung und den centralen Verlauf des Nervus acusticus des Kaninchens und der Katze. Virchow's Archiv, Bd. 119, H. 1, S. 81.

2. Von Bechterew, W.: Ueber die innere Abtheilung des Strickkörpers und den achten Hirnnerven. Neurol. Centralbl., Bd. IV (1885), S. 145.—Zur Frage über den Ursprung der Hörnerven. Neurol. Centralbl., Bd. VI (1887), S. 193.—Zur Frage über die Striae medullares des verlängerten Markes. Neurol. Centralbl., Bd. XI, 1892, S. 297.—Der hintere Zweihügel als Centrum für das Gehör, die Stimme und die Reflexbewegungen. Neurol. Centralbl., Bd. XIV (1895), S. 706.

3. Bumm: Experimenteller Beitrag zur Kenntniss des Hörnervenursprungs beim Kaninchen. Allgem. Zeitschrift f. Psych., Bd. 45, S. 568.—Experimentelle Untersuchungen über das Corpus trapezoides und den Hörnerven der Katze. Festschr. zur 150 jähr. Stiftungsfeier der Univ. Erlangen, Wiesbaden, 1893; Abstract Neur. Centralbl., Bd. XIII (1894), S. 448.

4. Cajal, Ramón y S.: Beitrag zum Studium der Medulla oblongata des Kleinhirns und des Ursprungs der Gehirnnerven. Deut. Uebersetz. von Bresler. Leipzig, 1896.

5. Cramer, A.: Beiträge zur feineren Anatomie der Medulla oblongata und der Brücke mit besonderer Berücksichtigung des 3.–12. Hirnnerven. Jena, 1894.

6. Flechsig, P.: Zur Lehre vom centralen Verlauf der Sinnesnerven. Neurol. Centralbl., Bd. V (1886), No. 23.—Weitere Mittheilungen über die Beziehungen des unteren Vierhügels zum Hörnerven. Neurol. Centralbl., Bd. IX, 1890, S. 98.

7. Forel: Vorläufige Mittheilung über den Ursprung des Nervus acusticus. Neurol. Centralbl., Bd. IV, 1885, S. 101.

8. Held, H.: Die centralen Bahnen des Nervus acusticus bei der Katze. Arch. f. Anat. und Phys., Anat. Abth., 1891.—Die Endigungsweise der sensiblen Nerven im Gehirn. Arch. f. Anat. u. Phys., Anat. Abth., 1892.—Die centrale Gehörleitung. Arch. f. Anat. u. Phys., Anat. Abth., 1893.—Ueber eine directe acustische Rindenbahn und den Ursprung des Vorderstrangrestes beim Menschen. Arch. f. Anat. u. Physiol., Anat. Abth., 1892.

9. Kirilzew: Zur Lehre vom Ursprung und centralen Verlauf der Gehörnerven. Vorläufige Mitth., Neurol. Centralbl., Bd. XI (1892), S. 669.

10. Von Kölliker: Der feinere Bau des verlängerten Markes. Anat. Anzeiger, Bd. VI (1891), S. 427–431; Handbuch der Gewebelehre des Menschen, 6 Aufl., II. Bd. 1893.

11. Martin, P.: Zur Endigung des Nervus acusticus im Gehirn der Katze. Anat. Anzeiger, Bd. IX (1894), S. 181.

12. Von Monakow: Ueber den Ursprung und den centralen Verlauf des Nervus acusticus. Correspondenzblatt f. Schweizer Aerzte, 1887, No. 5; Abstract in Neurolog. Centralblatt, Bd. VI, 1887, S. 201.—Striae acusticae und untere Schleife. Arch. f. Psych. u. Nervenkr., Bd. XXII, S. 1.

13. Onufrowicz, B.: Experimenteller Beitrag zur Kenntniss des Ursprungs des Nervus acusticus des Kaninchens. Arch. f. Psych. und Nervenkr., Bd. XVI, S. 711.

14. Roller: Die cerebralen und cerebellaren Verbindungen des 3.–12. Hirnnervenpaares. Die spinalen Wurzeln der cerebralen Sinnesnerven. Allgem. Zeitsch. f. Psych., Bd. XXXVIII (1882), S. 228.

15. Sala, L.: Sur l'origine du nerf acoustique. Arch. ital. de biol., t. XVI, 1891, p. 196; also in Monitore zoologico italiano, Florence, Ann. II (1891), and in Neurol. Centralbl., Bd. XI, 1892, S. 200.

Legends for Figures.

Fig. 1. Diagram representing flat reconstruction of the nuclei of reception of the cochlear and vestibular nerves. The line *a, a* represents the lateral wall of the ventricle; the line *b* corresponds to the lateral outline of the corpus restiforme; the line d_1 to d_4, d_1 to d_3, and the line *e, e, e* correspond to sulci in the floor of the fourth ventricle; *C. d.*, nucleus nervi cochlearis dorsalis; *C. v.*, nucleus nervi cochlearis ventralis; the graduated line corresponds to the middle line of the floor of the ventricle. *Floc.*, flocculus; *K. VII*, knee of nervus facialis; *L.*, medial portion of nucleus nervi vestibuli lateralis (Deiters); L_1, lateral portion of nucleus nervi vestibuli lateralis (Deiters); *M* together with *y*, nucleus nervi vestibuli medialis (Schwalbe); *Nuc. XII*, nucleus nervi hypoglossi; *Nuc. VI*, nucleus nervi abducentis; *P. f.*, pedunculus flocculi; *N. m. p. V.*, nucleus motorius princeps nervi trigemini; *N. o. s.*, nucleus olivaris superior; *N. s. V.*, nucleus nervi trigemini (sensory); *N. c.*, root bundle of nervus cochleæ; *N. vest.*, root bundle of nervus vestibuli; *R. d. n. ve.*, radix descendens nervi

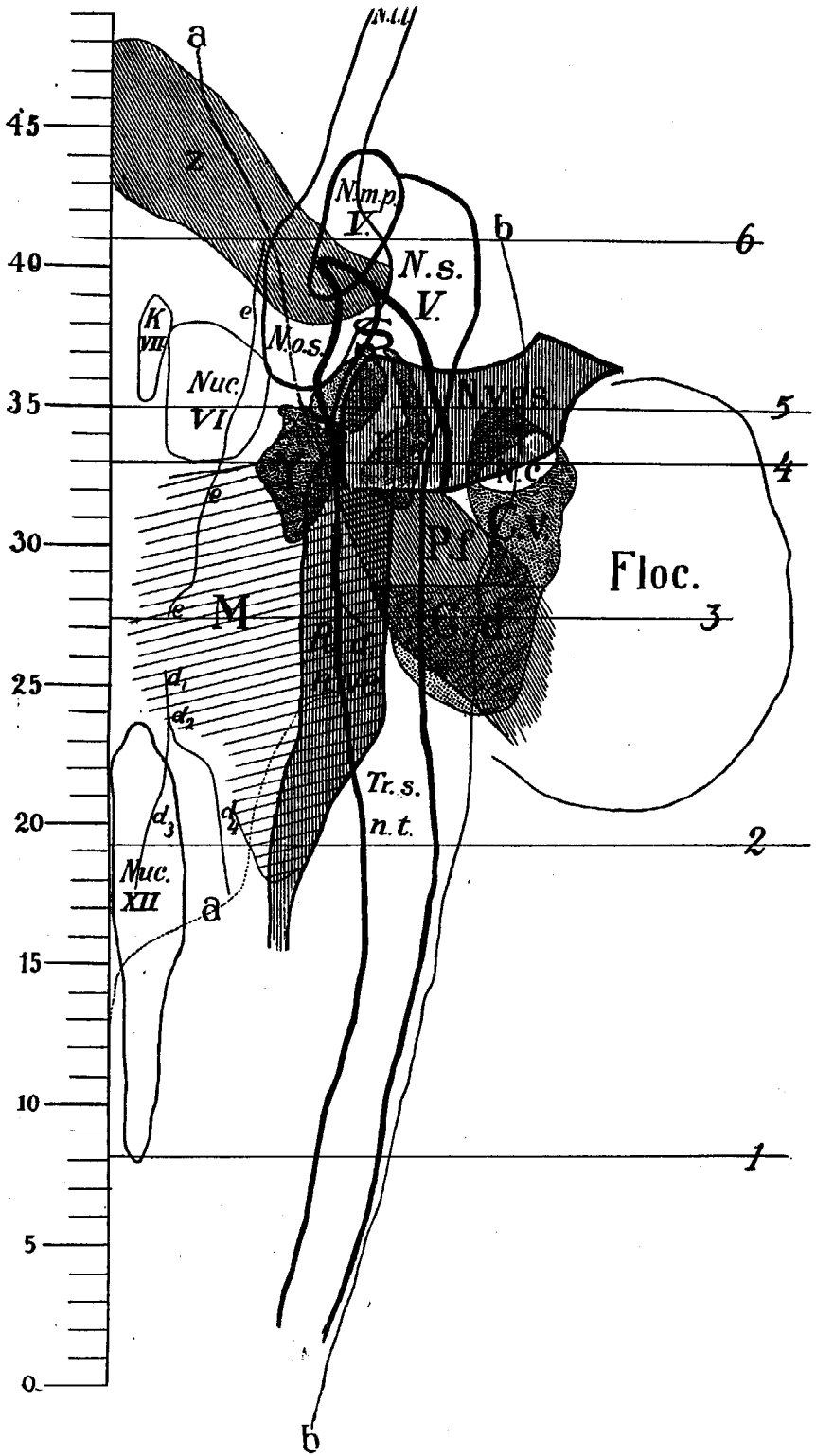

FIG. 1.

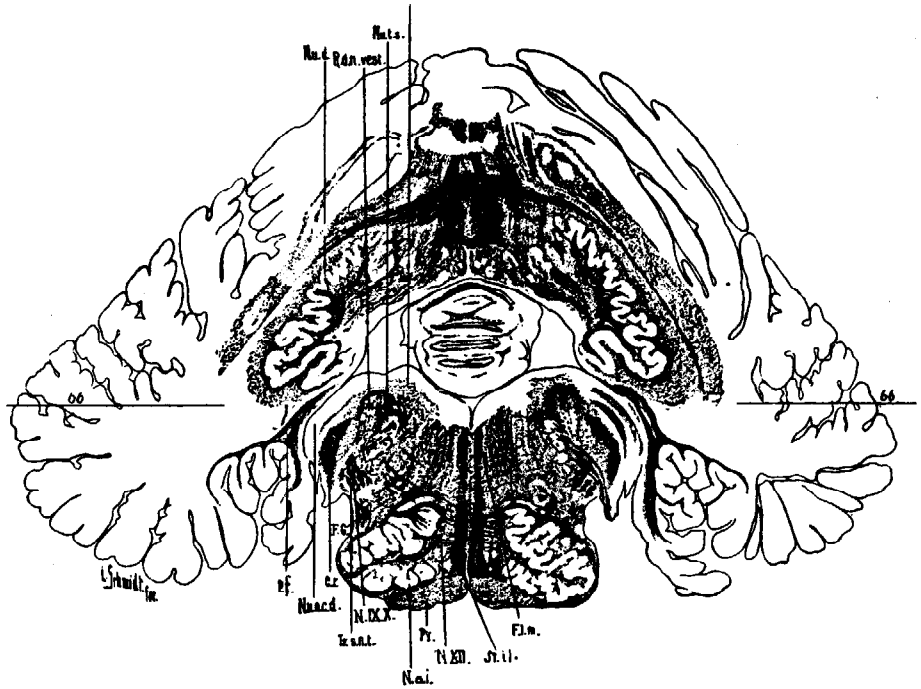

FIG. 2.

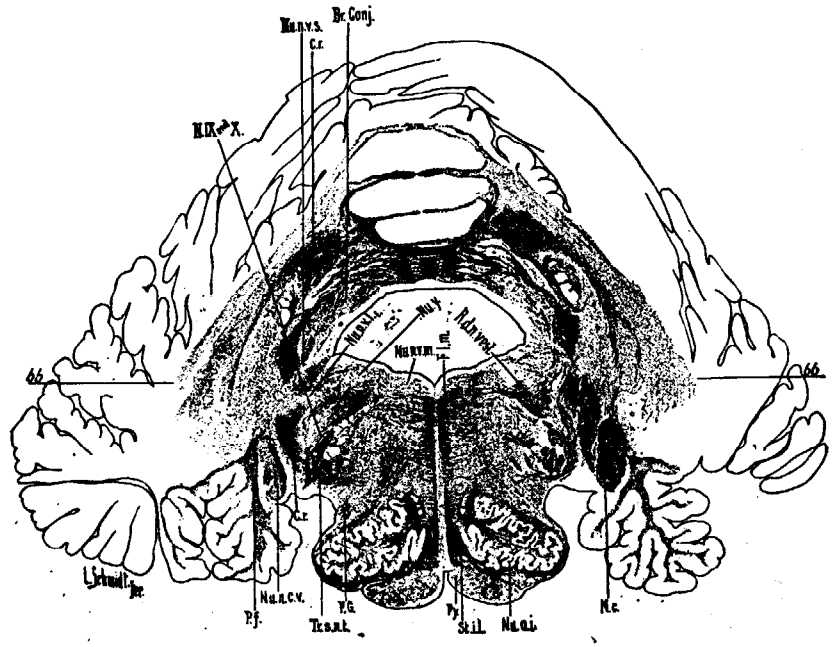

FIG. 3.

vestibuli; *S.*, nucleus nervi vestibuli superior (Bechterew) (area enclosed in the broad black line); *Tr. s. n. t.*, tractus spinalis nervi trigemini; *Y*, nucleus *y*, antero-lateral portion of nucleus nervi vestibuli medialis; *z*, decussatio nervi trigemini.

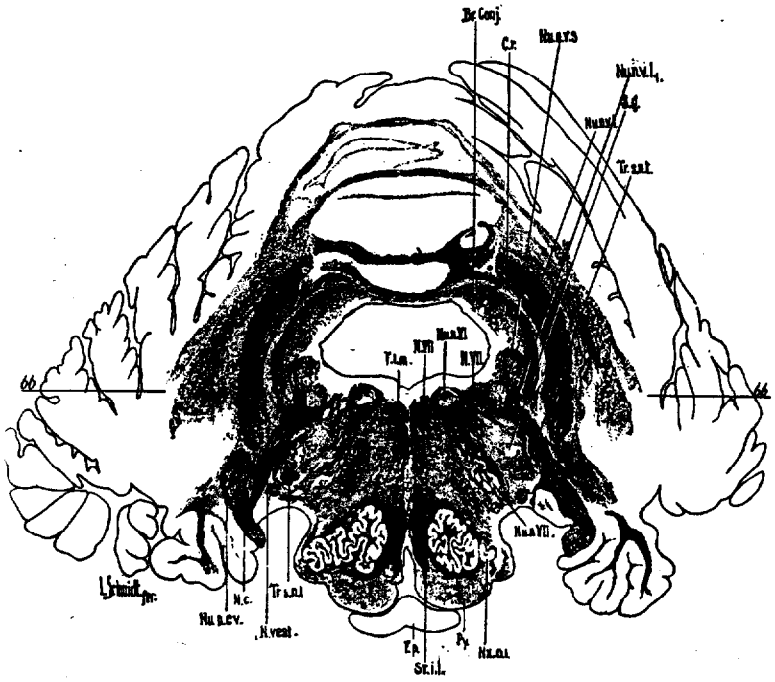

FIG. 4.

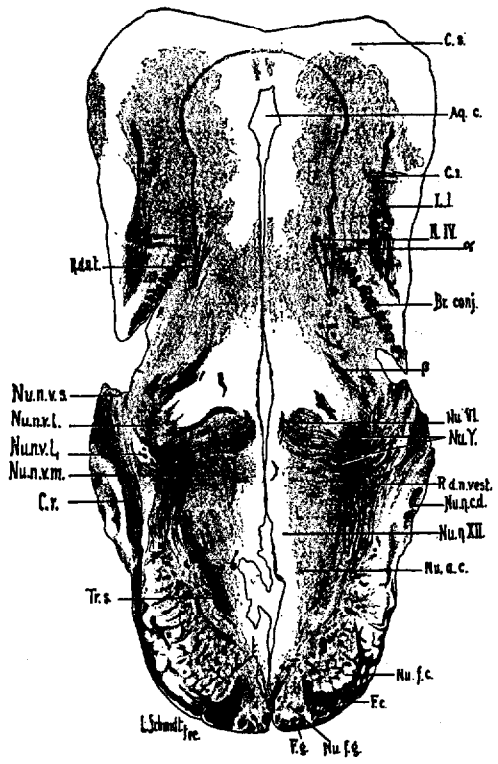

FIG. 5.

Fig. 2 (corresponds approximately to line 3 on the diagram, Fig. 1). *C. r.*, corpus restiforme; *F. G.*, fasciculus ventro-lateralis (Gowersi); *F. l. m.*, fasciculus longitudinalis medialis; *N. XII*, root bundles of the nervus hypoglossus; *Nu. d.*, nucleus dentatus cerebelli; *Nu. n. c. d.*, nucleus nervi cochlearis dorsalis; *N. o. i.*, nucleus olivaris inferior; *Nu. n. v. m.*, nucleus nervi vestibularis medialis; *Nu. t. s.*, nucleus tractus solitarius; *Py.*, pyramis; *R. d. n. vest.*, radix descendens nervi vestibuli.

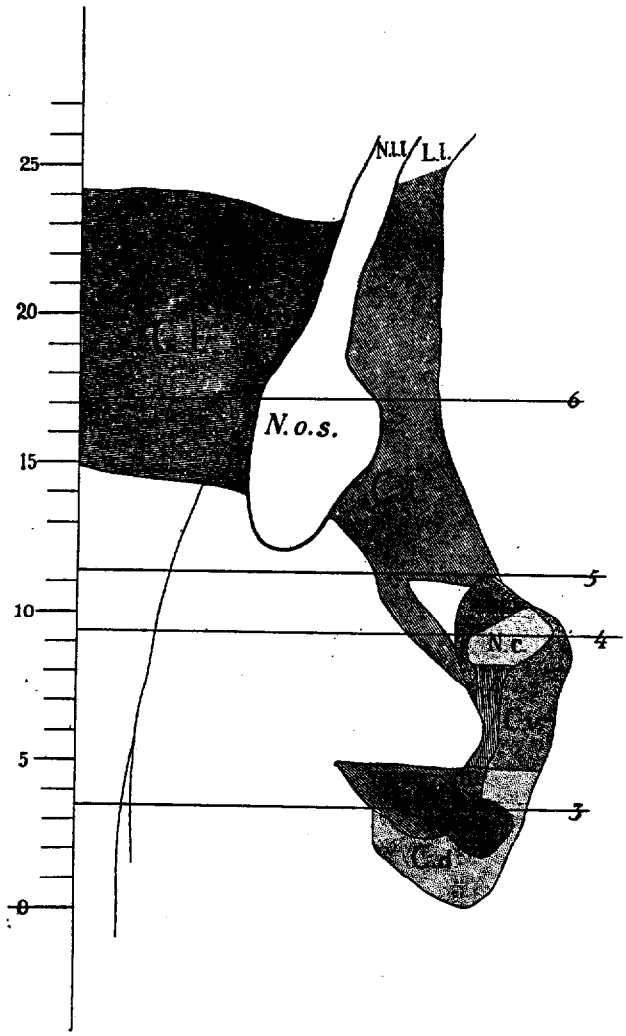

FIG. 6.

Fig. 3 (corresponds approximately to line 4 on the diag. Fig. 1). *Br. Conj.*, brachium conjunctivum; *C. r.*, corpus restiforme; *F. G.*, fasciculus ventro-lateralis (Gowersi); *F. l. m.*, fasciculus longitudinalis medialis; *N. c.*, nervus cochleæ; *N. IX and X*, nervus glossopharyngeus et vagus; *Nu. n. c. v.*, nucleus nervi cochlearis ventralis; *Nu. n. v. l.*, nucleus nervi vestibularis lateralis (Deiters); *Nu. n. v. m.*, nucleus nervi vestibularis medialis (Schwalbe); *Nu. n. v. s.*, nucleus nervi vestibularis superior (Bechterew); *Nu. o. i.*, nucleus olivaris inferior; *Nu. y.*, nucleus *y* (anterior-lateral portion of nucleus nervi vestibularis medialis); *P. f.*, pedunculus flocculi; *Py.*, pyramis; *R. d. n. vest.*, radix descendens nervi vestibuli; *St. i. l.*, stratum interolivare lemnisci.

Fig. 4 (corresponds approximately to line 5 on the diagram, Fig. 1). *Br. Conj.*, brachium conjunctivum; *C. r.*, corpus restiforme; *F. l. m.*, fasciculus longitudinalis medialis; *F. p.*, fibræ pontis; *N. c.*, nervus cochleæ; *N. VII*, nervus facialis;

N. vest., nervus vestibuli; *Nu. n. VI*, nucleus nervi abducentis; *Nu. n. VII*, nucleus nervi facialis; *Nu. n. c. v.*, nucleus nervi cochlearis ventralis; *Nu. o. i.*, nucleus olivaris inferior; *Py.*, pyramis; *S. g.*, substantia gelatinosa; *St. i. l.*, stratum interolivare lemnisci; *Tr. s. n. t.*, tractus spinalis nervi trigemini.

Fig. 5 (section 66, horizontal series). *a*, fibres extending between lateral lemniscus and brachium conjunctivum; *Aq. c.*, aqueductus cerebri; *β*, decussating fibres of nervus trigeminus; *C. i.*, colliculus inferior; *C. r.*, corpus restiforme; *C. s.*, colliculus superior; *F. c.*, fasciculus cuneatus; *F. g.*, fasciculus gracilis; *L. l.*, lemniscus lateralis; *N. IV*, root fibres of nervus trochlearis; *Nu. a. c.*, nucleus alæ cinereæ; *Nu. n. c. d.*, nucleus nervi cochlearis dorsalis; *Nu. f. c.*, nucleus funiculi cuneati; *Nu. f. g.*, nucleus funiculi gracilis; *Nu. n. v. l.*, nucleus nervi vestibularis lateralis (pars medialis); *Nu. n. v. l*$_1$, nucleus nervi vestibularis lateralis (pars lateralis); *Nu. n. v. m.*, nucleus nervi vestibularis medialis; *Nu. n. v. s.*, nucleus nervi vestibularis superior (Bechterew); *Nu. n. XII*, nucleus nervi hypoglossi; *Nu. VI*, nucleus nervi abducentis; *Nu. Y*, nucleus *y* (antero-lateral portion of nucleus nervi vestibularis medialis); *R. d. n. t.*, radix descendens nervi trigemini; *R. d. n. vest.*, radix descendens nervi vestibuli; *Tr. s.*, tractus solitarius.

Fig. 6. Diagram representing flat reconstruction of nuclei nervi cochlearis and corpus trapezoideum. *C. d*, nucleus nervi cochlearis dorsalis; *C. t.*, corpus trapezoideum; *C. v.*, nucleus nervi cochlearis ventralis; *h.*, portion of root bundle of cochlear nerve running past the ventral cochlear nucleus to the region of the dorsal cochlear nucleus; *l.*, area occupied by medullated fibres of lateral portion of dorsal cochlear nucleus; *m.*, area occupied by medullated fibres in the medial portion of the dorsal cochlear nucleus; *L. l.*, region of lemniscus lateralis; *N. c.*, nervus cochleæ; *N. o. s.*, complex of nucleus olivaris superior.