IX. *Researches on the Intimate Structure of the Brain.*—Second Series.

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CHAPTER I.

(1) Before I begin to describe the parts which form the subject of this communication, and to show how some of them are merely modified portions or developments of others that belong to the *medulla oblongata*, it will be advisable to recur to those morphological changes in the medulla, which I formerly pointed out as themselves arising from modifications of the *spinal cord*. And while in unravelling structures so extremely complex, such a course seems almost necessary to facilitate their comprehension, and convey to the reader a just notion of their morphological changes, in relation on the one hand, to the remaining parts of the encephalon, and on the other hand, to the spinal cord, it will afford me an opportunity of adding to this recapitulation some new facts that have been elicited by subsequent observation and a more extended experience.

It is gratifying to know that many of the results of my previous researches have been found to throw considerable light on certain diseases of the nervous system, especially on some forms of paralysis; and my own pathological investigations, as well as a close study of nervous disorders, have not only enabled me to shape my present researches as much as possible in accordance with the requirements of the pathologist, but, by pointing to the probability of certain anatomical connexions suggested by morbid symptoms, they have sometimes been the means of directing the course of my dissections in a very peculiar way*.

Some of the results comprised in this communication were obtained by adopting the method of dissection which I so strongly recommended in my former Memoir on the Medulla Oblongata. This plan consists in first making a number of delicate and careful dissections in the course of the fibres of the medulla, after it has been well hardened in strong spirit of wine, and then examining microscopically thin sections, made in different directions, and rendered transparent by the method which is known as my own. By this means we may often succeed in unravelling structures which are so complex that the investigation at first sight appears to be almost hopeless. Before the first dis-

* Dr. Hughlings Jackson (Physician to the Hospital for Paralysis and to the London Hospital) was the first to apply with great ability and industry the recent advances made in the minute anatomy of the nervous centres to the explanation of certain forms of paralysis. See especially 'The London Hospital Reports,' vols. i. and ii.; 'Ophthalmic Hospital Reports,' vol. v., &c.

section is begun, the hardened medulla should be macerated for a few days in strong spirit to which a small quantity of liquor potassæ has been added.

(2) At the highest point of the spinal cord, that is, at the first pair of cervical nerves, a transverse section of both the white and grey substances has the appearance represented in fig. 1, Plate VIII. Here the central grey substance (*t*) surrounding the canal, is of considerable size and of somewhat quadrangular shape. The neck of the posterior horn, *cervix cornu posterioris*, between *b'* and *o*, is very slender, and after stretching obliquely outward and backward from the middle line, terminates in a tuft or expanded extremity (*e*), which I have named the head or *caput cornu posterioris*. Between the central canal and the bottom of the anterior median fissure (*z*) are seen the decussating fibres of the *anterior commissure* extending on each side into the anterior white column; and in the deep and somewhat oval space (*d'*) of the lateral column (*d*) is a beautiful network of nerve-fibres and blood-vessels extending from the borders of the surrounding grey substance, and enclosing in its meshes a number of separate fasciculi which, a little higher up, in the medulla oblongata, cross over to the opposite side in front of the canal, and with the corresponding fibres of the anterior commissure, form the opposite anterior pyramids (see fig. 2). This network in the lateral columns contains a number of cells of different shapes and sizes, and which in animals are larger and more numerous than in Man.

(3) At the lower part of the medulla oblongata, that is, at the points of the anterior pyramids, a transverse section presents the appearances delineated in fig. 2. Here the central grey substance (*t*) has become narrower laterally, but has increased a little in depth from before backward in the middle line, and the posterior cornua (*b'*, *o*, *e*) are somewhat depressed or thrown more to the *side* of the medulla. The head or caput cornu posterioris (*e*) has increased in size, and begun to detach itself from the extremity of the cervix (*o*), being joined to it only by a small network containing slender bundles of longitudinal fibres, while the *cervix* itself has become a little thicker and more bulbous. Meanwhile, the bundles of longitudinal fibres contained in the meshes of the lateral columns cross over to the opposite side and plunge into the anterior columns to form the anterior pyramids at *z*. Ascending a little higher in the medulla (fig. 3), we find that while the *caput cornu posterioris* continues gradually to enlarge, it becomes more and more detached from the extremity of the cervix, or rather, is joined to it only by an increase of the intervening network already mentioned. At the same time the central grey substance (*t*) is encroached upon at the sides of the canal by the bundles of the lateral columns destined for the anterior pyramids; so that it has now a triangular shape, and together with the posterior cornua has some resemblance to a bird with both its wings expanded. From the root (*b'*) of the posterior cornu, on each side of the posterior median fissure, there now arises a grey network of fibres and blood-vessels containing nerve-cells and extending backwards through the posterior pyramid (*b*) to form the rudiment of its grey nucleus, or the post-pyramidal ganglion. Still further out, or nearer its extremity, the surface of the cervix cornu is raised into an eminence (*o*) which

projects into the restiform body (*c*) and constitutes its grey nucleus, or the restiform ganglion. In figs. 4 & 5, we find the same changes carried to a still greater extent. In the latter the decussating bundles of the anterior pyramids come only from the central grey substance and roots of the anterior cornua at the sides of the canal, and scarcely at all, as they did in fig. 4, from the lateral columns (*d'*), in which now the original network is again distinguishable; but it is larger, closer, more beautiful than we found it in fig. 1, and contains in its meshes bundles that have no share in the formation of the anterior pyramids*. The central grey substance, on each side of the median line, with the corresponding cornu, are now represented by *t' t b' o e* (compare figs. 1, 2, 3, 4 & 5). In fig. 6, which represents a transverse section a little higher up, just below the bulb of the posterior pyramids, we see that the *anterior* part (*t'*) of the central grey substance immediately surrounding the canal, is distinct from the posterior part (*t*), which covers it as by a kind of slanting roof. This latter is the vesicular tract or nucleus which gives origin to the upper roots of the spinal-accessory nerves. The anterior part (*t'*) is the vesicular tract or nucleus of the hypoglossal nerve, and is the analogue of a portion of the anterior or motor cornu of the spinal cord. These cornua are now scarcely distinguishable, but their places are traversed by roots of the hypoglossal nerves in their passage outward from their nuclei. Traversed also by these roots, and lying on the outer and back part of each anterior pyramid (*y*), is a layer of small cells which, higher up, form the anterior or inner part of the lamina of the olivary body (*h*, figs. 7 & 8). On the outer side of this *layer* is another distinct group of cells (*s*) connected by a network in the lateral column, and by nerve-fibres from the grey tubercle (*e*). This is the *antero-lateral* nucleus. Meanwhile the post-pyramidal and restiform nuclei (*b'*, *o*) have increased in size, and from these, especially the post pyramidal, proceed the chief portion of the decussating fibres which sweep round the front of the canal to enter the anterior pyramids.

(4) In ascending the medulla, the changes just described continue to increase in extent, and an important modification may be observed to take place. Fig. 7 represents a transverse section on a level with the lower part of the olivary bodies. Here the posterior pyramid (*b*) is nearly filled with its grey substance (*b'*); and that of the restiform body (*o*) has also greatly increased, although it is still covered by a considerable layer of white substance (*c*), by which it is separated, on the one side, from the postpyramidal nucleus (*b'*), and on the other side from the grey tubercle of Rolando (*e*). The spinal-accessory nucleus (*t*) and the hypoglossal nucleus (*t'*) have become enlarged and somewhat modified in shape. The latter (*t'*), on each side and in front of the elongated canal, now contains the large multipolar cells which give origin to the upper roots of the hypoglossal nerve (*x*). As in fig. 6, a number of fibres proceeding from the posterior pyramids (*b'*) sweep round in a direction forward and inward, and decussate in front of the hypoglossal nucleus; but instead of plunging into the opposite anterior *pyramid*, as they did in fig. 5, they terminate in the opposite *lateral and olivary column*. Further outward and forward, other arciform fibres, proceeding from the grey tubercle (*e*), and

* See my memoir on the Medulla Oblongata, fig. 19, Plate XV. Philosophical Transactions, Part I. 1858.

grey substance of the restiform body (*o*), sweep through and around the olivary bodies (*w*), some of them decussating in bundles across the back of the anterior pyramids (*y*), and assisting in forming the commissure of the olivary bodies.

(5) If we examine a transverse section of the medulla a little higher up, at the point of the calamus scriptorius, as in fig. 8, we find that the posterior pyramid (b') is not only thrown somewhat aside, but is a little more flattened, and more overlays the restiform body (*o*), from the grey substance of which it is separated only by a smaller quantity of white substance, as seen at b'' on the right side of the figure, where the dotted line indicates its outer boundary. At the same time the grey substance of the restiform body (*o*) has not only increased, but become more irregularly scattered in groups or patches through its white substance, as seen on the right side. It will be observed also that the spinal-accessory nucleus (*t*) has not only increased in size, but has begun to split into two lateral halves, by an antero-posterior fissure, at the bottom of which the central canal has still a distinct existence.

(6) On a level with the middle of the olivary bodies, the vesicular column which gave origin to the spinal-accessory nerve now gives origin to the vagus nerve, and may therefore be called the *vagal* nucleus. As shown in a transverse section (fig. 9, *g*), it is much larger than in the preceding figure, and has become completely divided by its median fissure into two lateral halves which are thrown widely apart at the floor of the fourth ventricle. It will be seen also that the increase in the size of the vagal nucleus takes place posteriorly, and apparently at the expense of the inner and under part of the posterior pyramid (*b*), upon which it encroaches; for it is evident that this pyramid, the limit of which is indicated by the dotted line (on the right side), is smaller here than in fig. 8. At the same time the grey substances of the posterior pyramid and restiform bodies have coalesced, the *white* portion of the restiform body which previously separated the two being now filled with its grey substance.

(7) A transverse section at a somewhat higher level presents the appearances seen on the left side of the medulla in fig. 10. Here t' is a section of the hypoglossal nucleus; *g* is a section of the upper end of the oval nucleus of the vagus nerve (*g*, fig. 11, Plate IX.), separating t' from *i*, which is a section of the auditory nucleus; *n* represents a longitudinal fasciculus of fibres of the lateral column between the two horns of *g*, the vagal nucleus; c' *o* is a section of the upper end of the pyriform grey substance of the restiform and postpyramidal bodies seen at *o*, fig. 12, Plate IX., and forming part of the auditory nucleus; and *p* is a section of the superficial grey substance (*p*, fig. 12) of the restiform body, covered by arciform fibres, as shown at A, fig. 13, which represents a lateral view of the medulla oblongata.

(8) Having thus briefly described these elementary structures of the medulla oblongata as they are seen in transverse sections, I will now exhibit them in longitudinal dissections, and employ, as far as possible, the same letters to indicate the same parts.

The posterior surface of the medulla oblongata, especially in the neighbourhood of the fourth ventricle, presents a greater diversity of appearance, amongst different indi-

viduals in Man, than in mammalia of the same species; but the general arrangement of the parts is nevertheless the same in all. Fig. 11, Plate IX. represents the posterior aspect of the medulla oblongata of a healthy middle-aged man who died in consequence of an accident: *a* is the cut surface of the lower end of the medulla, near the level of the points of the anterior pyramids. Adjoining the median sulcus, on each side, is the posterior pyramid (*b*), which, as it ascends to the point of the calamus scriptorius, expands into a thick bulbous mass (*b'*), and then diverges as a flattened band. External to the pyramid is the restiform body (*c*), which also enlarges as it ascends to the same level. Between this and the posterior edge of the antero-lateral column (*d*) is a superficial tract of grey substance (*e*), consisting of the expansion of the caput cornu, or dilated extremity of the posterior horn, and known as the grey tubercle of ROLANDO.

(9) At the point of the calamus scriptorius, on each side of the median line, is an oval or pyriform mass of ganglionic substance (*g*), of a bluish or pearly hue, constituting the superficial part of the nucleus of the vagus nerve, seen in section at *g*, fig. 9, Plate VIII.; and the small tract (*t'*) between this and the median fissure is the *upper* part of the nucleus of the hypoglossal nerve, seen in section in fig. 10, Plate VIII.; its *lower* end being covered in by the spinal-accessory nucleus and the posterior pyramids (*t*, *b'*, figs. 6, 7 & 8, Plate VIII.). In the angle between the outer side of this vagal nucleus (*g*, fig. 11, Plate IX.) and the upper divergent end of the posterior pyramid (*b'*), is the commencement of another and larger mass of grey substance (*i*), which is seen in section in fig. 10, Plate VIII., and forms the posterior nucleus of the auditory nerve, covered by epithelium.

(10) If the posterior pyramid *b b'* (*on the left side*) be carefully dissected from the restiform body (*c*), from below upwards, and be thrown forward, as shown in fig. 12, Plate IX., the exposed surface of the medulla will present the appearances delineated at the lower half of this figure; *t* is the downward continuation of the vagal nucleus or tract, constituting the nucleus of the spinal-accessory nerve, and previously covered in by the bulb of the posterior pyramid (*b'*), as shown at *t*, fig. 7, Plate VIII. in a transverse section. The oval mass *g*, marked off by the dotted line, is the inner and posterior portion of the *vagal* nucleus exposed at the point of the calamus scriptorius by the divergence of the posterior pyramid; *l* is its inner and more anterior portion, *covered*, like the spinal-accessory nucleus *t*, lower down, by the posterior pyramid, as seen in transverse sections, figs. 8 & 9, Plate VIII. Its upper point (*m*) forms the principal nucleus of the glossopharyngeal nerve. Along the outer and anterior part of this grey tract is a slender, longitudinal white column (*n*), which it lodges, as it were, in a groove (see *n*, fig. 9, Plate VIII.), and which tapers to a point as it descends obliquely inward along the base of the posterior pyramid to the mesial line (see *n*, fig. 12). In its course upward it ascends along the inner edge of the pyramid, and joins those fibres of the latter which pass into the anterior or outer auditory nucleus (see *n*, fig. 42, Plate XII., and fig. 58, Plate XIV.). On the outer side of this slender white column is a somewhat fusiform mass of grey substance, *o* (fig. 12, and *o o'*, fig. 24, Plate X.), imbedded

in the inner side of the restiform body, and exposed by the removal of the posterior pyramid. From the upper end of this fusiform grey mass a thin but broad layer of fibres, mixed with some grey substance (*p*), radiates upward and outward on the restiform body (see also *p*, fig. 24).

Fig. 14, Plate IX. is another careful dissection of some of these parts. The posterior pyramid (*b*) has been separated on the left side of the medulla from the inner side of the posterior column (*c*), and drawn aside, exposing nearly the whole of the continuous tract of grey substance constituting below, the *spinal-accessory* nucleus (*t*), and above, the *vagal* nucleus (*g*). This grey tract is intimately connected and continuous at the point of the calamus with the posterior pyramid (*b*), which sends forward into it a series of fine fibres. It is composed of round, oval, crescentic, or angular cells of large size, and a multitude of very fine fibres, of which a large number are longitudinal, and ascend with an inclination outward from *t* to the calamus scriptorius at *g*, where those on the outer side are connected with the posterior pyramid, from which again a bluish process runs forward to the oval or vagal mass left uncovered by the posterior pyramid at *g*, as shown in fig. 12.

(11) I will now briefly describe, in a series of transverse sections, the medulla oblongata of the Monkey, not only because it exhibits certain interesting deviations from the appearances observed in Man, but because it illustrates in a beautiful manner the highly important morphological changes which I have just been endeavouring to explain.

In the lower kind of Apes it differs considerably in shape from the human medulla, the antero-posterior diameter being less than the lateral, but proportionably greater than in other animals. The form and arrangement of its different parts may be considered to possess a kind of intermediate character between man and the higher mammalia. The anterior pyramids and olivary bodies are proportionably larger than in any inferior animal, and, as in Man, are the chief cause of the increase in the antero-posterior diameter of the medulla. The posterior and lateral white columns are largely developed and very distinctly marked off from each other by indentations, as in some of the mammalia, especially of the feline species. Fig. 15, Plate IX. represents the grey substance at the lower part of the medulla on a level with the points of the anterior pyramids. It has a greater resemblance to the corresponding portion in Man than in any other animal, but it differs from both in being pierced behind the canal by a greater number of longitudinal bundles of fibres, represented by the four dark dots*; d'' is a close network with nerve-cells springing out of the side of the anterior cornu, and forming, higher up, the *lateral nucleus*. Fig. 16, Plate IX. is an exact representation of the grey substance at a level corresponding very nearly to the same part in fig. 4, Plate VIII. of the human medulla. Fig. 17, Plate IX. shows both the white and grey substances still higher up, at a point nearly corresponding to that of fig. 5, Plate VIII. Here it will be seen that the posterior pyramids (*b*, *b*), and especially the restiform bodies (*c*, *c*), are largely developed. The lateral columns (*d*, *d*) are particularly large, and the posterior

* The same letters indicate the same parts as in all the preceding figures of the human medulla.

parts of them are separated from the rest of the antero-lateral columns by a deep notch on each side. Fig. 18, Plate IX. represents the posterior part of the right lateral half of the medulla somewhat higher up. Here the posterior pyramid (*b*) has increased in dimensions and become completely filled with grey substance. The restiform body (*c*) has also enlarged and is singularly prominent. The grey substance differs in some respects from that of the human medulla. The part *o* of fig. 17 has now enlarged into a broad mass, from which a multitude of conspicuous fibres radiate like a brush to a remarkable group of cells situated near the surface of the column (*c*). These cells are much larger and more diversified in shape than those of the *inner* part (*o*) of the restiform nucleus, and are united together by their processes in a network. This grey mass exists likewise in Man, but is not so largely developed. It is seen to commence in fig. 5, Plate VIII. at $c' c'$, as a small offset from *o*, and to increase in size through the rest of the figures. In Man there are many more fibres constituting the network than in the Ape, and the cells are somewhat smaller and more elongated. Fig. 26, Plate X. represents some of the cells from the Ape, magnified 220 diameters. They are in close vicinity of bundles of longitudinal fibres. In fig. 19 this outer nucleus of the restiform body has increased in dimensions, and is united immediately, instead of by radiating fibres, to the inner restiform nucleus (*o*), which, like the posterior pyramid (*b*), is also larger than in the preceding figure. This inner nucleus (*o*) is now seen to consist of numerous oval, globular, crescentic, or irregular masses of granular substance, with small, and, for the most part, round, oval, or pyriform cells, which contrast strongly with the large, variously-shaped, and branched cells of the outer nucleus (c'). At each side of the canal, $t\,t'$ has now taken the form of an oval mass, the lower part of which has become the nucleus of the hypoglossal nerve; while the upper or posterior part (*t*), which is joined to its fellow by a light commissure, has become the nucleus of the spinal-accessory nerve. At this upper or posterior part it is directly continuous with the posterior pyramid (bb''); but its outer side is separated from *o*, the inner restiform nucleus, by two sets of fibres, the one proceeding from that nucleus and from the posterior pyramid, to the remains of the anterior cornu, and the lower end (W) of the olivary body of the *same* side; while the other set (*n*) proceed from the lateral column at the side of the spinal-accessory nucleus (*t*) to the olivary body, and back of the anterior pyramid of the *opposite* side ($y'y'$), decussating with their fellows from the other half of the medulla. As usual, the caput cornu (*e*), or dilated extremity of the posterior horn, has been pushed forward from its cervix by the development of the post-pyramidal and restiform ganglia (*b* and *o*). The anterior pyramids (*y*, *y*) are much larger than in any of the mammalia (compare figs. 13, 14, Plate XII., and figs. 15, 16, Plate XIII. of my Memoir on the Medulla Oblongata, Phil. Trans. 1858). Fig. 20, Plate IX. represents a transverse section of the right lateral half of the medulla of the Monkey, at the point of the calamus scriptorius, where the connexions between the spinal-accessory nuclei and the posterior pyramids of opposite sides are broken through. The two oval masses (t, t') are separated behind by the opening of the canal into the fourth ventricle, and resemble a pair of acorns joined at

their bases. In the lower or anterior part of each is seen the group of large cells (t') which form the hypoglossal nucleus; and in the upper or posterior part is seen another and oval group of smaller cells (t''), forming part of the nucleus of the spinal-accessory nerve. Behind this group of cells, the part t is finer in texture, consisting of granules, nuclei, small cells, and fine fibres. The posterior pyramid (b) is rather larger than in fig. 19, but it now begins to be bevelled off at its base, just below b; and between it and the spinal-accessory nucleus (t) there is a small triangular and paler mass (b''), which is in fact the inner side of the base of the pyramid, where it was joined to its fellow at the bottom of the median fissure, as seen at b'', fig. 19, enclosed in the dotted line on the right side. The outer restiform nucleus (c') has increased considerably in dimensions, while the inner nucleus (o) has somewhat diminished (compare figs. 7 & 8, Plate VIII. of human medulla on the right side). The decussating fibres (n, y') proceeding from the side of the spinal-accessory nucleus to the opposite olive and anterior pyramid are less numerous. In fig. 21, Plate IX. the outer restiform nucleus (c') is quite as large as in the preceding figure; while the inner nucleus (o) is much smaller, and is divided into several separate masses, which are partially blended with the outer nucleus (c'). The posterior pyramid (b) has considerably diminished, and the part b'' at its base has swollen into a larger eminence, which is now directly continuous with the posterior part (t) of the vagal nucleus, and seems to arise out of it (compare fig. 20), while its cells have increased somewhat in size. At the point between t and b'' there is an oval mass of epithelial cells and fibres (seen at t''' on the left side) which is continuous with the layer that covers the ventricle; it exists also in Man, but is much smaller than in the Ape. The hypoglossal nucleus (t') has increased considerably in dimensions, pushing, as it were, outward, the oval group of cells (t''), which now becomes the nucleus of the *vagus*, instead of the spinal-accessory nerve. The bundles of fibres (n, y') have ceased to proceed from the side of the spinal-accessory (now the vagal) nucleus to the opposite olive and anterior pyramid, the point whence they issued presenting now only the cut end of a slender column of longitudinal fibres (n) enclosed in a crescent between the horns of the nucleus. In fig. 22, Plate X. the outer restiform nucleus (c') and the scattered masses of the inner nucleus (o) have somewhat diminished and become still more intermixed. At the same time it will be observed that the posterior pyramid (b) is still further reduced, while the part b'' (which in fig. 20 belongs to the base of the pyramid) has extended in a corresponding proportion; so that now the posterior part (t) of the vagal nucleus, and the part b'' of the posterior pyramid form together a triangular mass (i) uniform in structure, and overlying the slender longitudinal column n and the oval group of cells (t'') which gives origin to the upper roots of the vagus nerve. The hypoglossal nucleus (t') reaches the surface of the ventricle, and completely separates i from its fellow of the opposite side. In fig. 23, Plate X. at p'' is seen a large bundle of arciform fibres coming from the outer part of the restiform body, and sweeping forward through the extremity of the caput cornu ($e\,e$) to the olivary body (W). The hypoglossal nucleus has considerably diminished, and retreated further backward and outward at the inner side of i,

and in the form of an uncircumscribed group of cells (t'); while the nucleus (t''), which now gives origin to the lowest roots of the glossopharyngeal nerve, instead of to the upper roots of the vagus, has been pushed, as it were, further outward, the bundles of the small longitudinal column (n) being now at the outer end of this nucleus, and separating the fibres of the nerve at their point of entrance. The posterior pyramid as a separate structure has wholly disappeared, while the triangular mass i, whose cells have been enlarging, is likewise increased in dimensions; and c' o of fig. 22 (the outer and inner nuclei of the restiform body) have now completely coalesced to form a beautiful network of cells and fibres (c' o), enclosing in its meshes longitudinal bundles of different shapes and sizes, and overlying, as in fig. 22, the extremity of the caput cornu posterioris (e e), through which transverse arciform fibres are sent across to the raphè to decussate with their fellows of the opposite side. Now the former of these two structures (i) gives origin (as I shall presently show) to the posterior root of the auditory nerve, and I have therefore termed it the *posterior* or *inner* auditory nucleus; while the latter ($c'o$) gives origin to the other division of the auditory nerve which passes underneath, or in front of the restiform body, and I have therefore termed it the *anterior* or *outer* auditory nucleus.

(12) By referring, then, to figs. 16, 17, 18, 19, 20, & 21, Plate IX. we find that (1°) the chief portion of the posterior pyramid with its grey substance, b', (2°) a large portion of the restiform body (c) with its grey substance (o) arising out of the posterior part of the cervix cornu posterioris (see especially figs. 17 & 18), and (3°) the posterior part of the central grey substance (t) which lies immediately beneath the pyramids, which gives origin to the grey substance of the pyramids, and which subsequently becomes itself the *posterior* part of the spinal-accessory and vagal nuclei (t t, figs. 20 & 21), are all by the histological and morphological changes above described transformed into the central organs of hearing, to say nothing at present of the similar relations of these to other parts of the brain.

Fig. 24, Plate X. is a longitudinal and horizontal section of the left half of the posterior part of the human medulla oblongata, presenting another view of the anatomical relations of the posterior pyramid, the restiform body, the vagal nucleus, and the auditory nucleus. At the lower end of the figure the section corresponds to the transverse horizontal line b'' b'' in fig. 6, Plate VIII., much below the point of the calamus scriptorius. b' is the grey substance of the pyramid, b is its white substance. Higher up the section takes off the surfaces of the inner and outer restiform nuclei (o c'), the former being still separated from the grey substance of the pyramid by its white substance (b). A little above this point the white substance of the posterior pyramid is lost, its grey substance being fused with that of the restiform body. At o' the section corresponds very nearly to the transverse line b'' b'' in fig. 9, Plate VIII., running through the middle of the vagal nucleus (g). Here the vagal nucleus has swollen into a large oval or pyriform body, while the posterior pyramid is much narrower and still more closely blended with the grey substance of the restiform body. Out of this united

mass several bundles of fibres with intervening layers of grey substance ascend longitudinally through the grey network with which they constitute the outer nucleus of the auditory nerve (*c' o*, fig. 23.). The inner nucleus (*i*, fig. 24) of the auditory nerve, although marked off from *g* by the dotted line to indicate its limits, is really directly continuous with it; neither can any alteration of structure be discovered, as the one passes into the other.

(13) I have been thus exact and particular in following out the gradual transitions and morphological changes which take place in ascending the medulla, not only on account of their extreme importance directly and indirectly in both a pathological and physiological point of view, but also on account of the necessity of understanding exactly the structure, connexions, and relations of the various elements of this part of the medulla, in order to interpret correctly the morphological and histological relations of the parts which are situated higher up. And indeed I believe that these changes which I have thus described, and which have cost me no small amount of thought and labour to follow out and confirm, will be the means of correcting many errors, and of leading to a more exact knowledge of other parts of the brain.

(14) But before I proceed to these parts it will be necessary to describe some new and important facts which I have recently ascertained with regard to the structure of the medulla oblongata.

In my former memoir on this subject, I gave the following composition of the anterior pyramids, according to my observations at the time:—

1. Decussating fibres of the anterior commissure, continuous with that of the spinal cord.

2. Decussating fibres from the opposite lateral columns, constituting their chief bulk.

3. Decussating fibres from the posterior grey substance.

4. Non-decussating fibres of the anterior columns, forming a small part on their outer side.

Now subsequent observations, while they have confirmed the truth of these statements, have enabled me to make some important additions. I had already shown that the decussating fibres from the posterior grey substance proceed out of the post-pyramidal nucleus, the restiform nucleus, and the posterior horn, near its extremity, as represented in figs. 3 & 4, Plate VIII. I have since ascertained, by means of longitudinal sections made at appropriate angles, that some of the decussating fibres of the anterior pyramids, which appear only to cross the antero-lateral *grey* substance, in their course from the opposite lateral column, do actually arise out of that substance at the points *d'*, *d'*, fig. 3, Plate VIII. I have further ascertained that the decussating fibres from both the posterior and the anterior grey substances *ascend toward the brain* after they have joined the pyramids. There is another exceedingly interesting structure, which, although it does not share in the formation of the anterior pyramid, I shall mention here, because it is mixed up with the decussating fibres of those bodies in the lateral column. In fig. 4, Plate VIII. on the right side, several curved bundles of fibres (*d'*) may be seen pro-

ceeding transversely outward to the lateral column, and crossing the fibres of that column which run to the opposite pyramid. These fibres take no share in the formation of the pyramids; and after running outward for a short distance they turn round and *descend* the cord obliquely across the longitudinal fibres of the lateral column. At the points where these two sets of fibres bend round (where the former or transverse set descend, and the lateral or longitudinal set become transverse as they cross to the opposite side) there is a very complicated and curved interlacement of bundles. Now the physiological importance of the former set is evident when we consider that the part of the posterior grey substance from which they arise is precisely that which forms the lower portion of the spinal-accessory and vagal nuclei, and with which the lower roots of the spinal-accessory nerves are connected. It is moreover interesting to observe that in ascending the medulla oblongata above the decussation of the pyramids, a similar system of fibres was found to proceed from the same respiratory centre, and to run down the lateral columns.

(15) Since the publication of my memoir on the medulla oblongata I have ascertained some further and important particulars regarding the structure and connexions of the respiratory centres. Fig. 25, Plate X. represents with great exactness a transverse section of the central canal with the left lateral half of the spinal-accessory and hypoglossal nuclei, at the level of the highest roots of the spinal-accessory nerve, as shown on a smaller scale in the entire transverse section of the medulla in fig. 8, Plate VIII. The spinal-accessory nucleus consists of two portions, an anterior and a posterior portion, which differ from each in structure, although they are closely connected. The posterior portion (A A, B, D, M, fig. 25, Plate X.) slopes outward and forward and is overlain by the posterior pyramid (see *b'*, fig. 8, Plate VIII.). It contains two or three thick longitudinal columns of grey substance, which in transverse section appear as oval or roundish masses (B, fig. 25, Plate X.), either wholly or only partially separated from each other. These masses consist of granules mixed with nuclei and small cells, and are enveloped by curved fibres and traversed by others in different directions. Some of the curved fibres at the outer borders of these masses run obliquely *outwards* and *downwards* along the medulla in straight lines to reach the base of the restiform body. Others from the anterior and posterior parts of the same or of different masses proceed *inward*, and, decussating across the middle line, connect these masses with their fellows of the opposite side (C C, fig. 25, Plate X.). This decussation of fibres is not observable in every section, and is most conspicuous a little lower in the medulla. Another set of fibres proceeding out of these masses run obliquely forward and outward (D) to the lateral column, and are joined by numerous others which issue from between the pyramids, at the bottom of the median fissure (E), and run on either side of the masses in the same direction. Those on the outer side (A A) curve forward and inward, and terminate in a plexus of bundles which decussate across the raphè (F) with their fellows in the opposite half of the medulla. They are interspersed with numerous small cells, of which some are darkened by pigment. The fibres on the inner side (G) run forward and

outward, partly into the lateral column (at *n*), accompanied by others from the masses B, but chiefly into the group of cells (H) forming the anterior portion of the nucleus, and are interspersed not only with small cells, but with numerous others of a larger kind, which are oval or fusiform, and elongated in the same oblique direction. They decussate with those in the opposite half of the nucleus across the central line at G. Many of them are evidently derived from a mass of epithelial cells situated at E between the bases of the posterior pyramids.

The anterior portion of the spinal-accessory nucleus consists of an oval or fusiform group of cells (H), sloping forward and outward from behind the canal. The cells are of various sizes, are mostly oval, and lie with their longer axes in both a transverse and longitudinal direction. Many of them are filled with dark pigment. From the outer and anterior extremity of this group fibres proceed to form the greater part of the spinal-accessory nerve *r*; and from its inner and posterior extremity another set of fibres extend obliquely inward and backward behind the canal, to the opposite group of cells. These commissural fibres, like the *others* that decussate between the opposite sides of the spinal-accessory nucleus, are not so distinct in Man as in the Ox, Sheep, Cat, Dog, or Rabbit, and are most conspicuous at a lower level of the medulla, especially at the inferior extremity of the olivary bodies, in sections corresponding to fig. 6, Plate VIII.

Between this group of cells in the anterior portion of the nucleus, and the curved outer fibres (A A) proceeding from the *posterior* portion, is a roundish or somewhat oval column of longitudinal bundles (*n*), either wholly or only partially enclosed on its posterior and inner sides by a band of fibres (M), which sweep forward and inward across the root of the spinal-accessory nerve *r*, and round the hypoglossal nucleus (J) to the median raphè (F), where they decussate with their fellows from the opposite half of the medulla. This little column is at intervals interspersed with small nucleated cells, sometimes united by a kind of network, and is, as I shall presently show, a structure of great importance.

I have already shown that at the lower end of the medulla oblongata, a network of fibres and cells is formed in the deep portion of the lateral column (*d'*, fig. 1, Plate VIII.) between the anterior and posterior horns; that from the meshes of this network proceed the bundles that form the chief proportion of the opposite anterior pyramid (figs. 2, 3, & 4); and that after these bundles have ceased to cross over, the original network reappears in a finer form (fig. 5, Plate VIII.) with an increase in the size and number of its cells, and containing in its meshes a multitude of bundles composed of finer fibres. Now the deepest or most internal and posterior of these longitudinal fibres (those lying immediately in front of the caput cornu or grey tubercle (*e*), at the angle formed by the lines L *n*, fig. 5, Plate VIII.) diverge from the rest as they ascend the medulla, and curving inward and backward, form the slender column *n* of fig. 8, Plate VIII. and fig. 25, Plate X. The derivation and course of this little column are well seen in a longitudinal section carefully made in a particular plane, that is, obliquely from behind forward in the direction of the line L *t*, fig. 8, Plate VIII., or almost in the course of

the spinal-accessory nerve, and carried downward through the parts of the medulla represented by figs. 7, 6, 5. From such a longitudinal section fig. 27, Plate X. was drawn. The lower edge (L *t*) of the figure corresponds to the line L *t* of fig. 5, Plate VIII. *d* is the superficial white substance of the lateral column, to the depth of the angle formed by the lines L O, fig. 5, Plate VIII. It consists of coarse longitudinal nerve-fibres, irregularly interlaced and crossed at right angles by some finer transverse fibres. *d'* is the posterior part of the network which reappears after the bundles in its meshes have ceased to supply the anterior pyramid, and corresponds to that part of the line L *t* in fig. 5, Plate VIII., which lies between O and *n*. It consists of finer fibres than those of the preceding or superficial white layer. These fibres are moreover collected into neat longitudinal bundles, which are very close together and parallel, but communicate with each other by very oblique lateral offsets, so as to enclose a multitude of fusiform, and often exceedingly elongated meshes, which are filled with groups and streaks of nucleated cells and nuclei, of a corresponding shape and size. Some of the processes of the cells extend along the longitudinal bundles, while others project across them in the plane of the section and in the direction of numerous fibres issuing from the spinal-accessory nucleus (*t t*).

As they ascend the medulla, the *deepest* longitudinal bundles (*n'*, fig. 27, Plate X.) of this layer diverge inwards, and become much more widely separated from each other, but still communicate by lateral offsets. At the upper border of the figure this portion of the layer (*n'''*) in the longitudinal section, occupies the part between N and *n*; and in a transverse section of the medulla at this level (fig. 8, Plate VIII.) it occupies that portion of the line L which also extends between N and *n*. Several of the innermost fibres, in ascending from *n'* (fig. 27, Plate X.), unite into bundles to form the slender longitudinal column *n*, which increases in thickness and curves inward and backward as it approaches the upper border of the figure. In fig. 8, Plate VIII., this little column (*n*) is seen in transverse section. In the transverse section (fig. 5, Plate VIII.), which corresponds to the lower border of the longitudinal section (fig. 27, Plate X.), it is at first separated from the spinal-accessory nucleus (*t*) by the numerous bundles of transverse fibres which sweep round from behind forward to decussate into the anterior pyramid. In the longitudinal section (fig. 27, Plate X.), the cut ends of these transverse bundles are represented at the lower border of the figure by the dark dots at *n''*. They are contained in the transversely elongated meshes of a network composed chiefly of fibres proceeding from the spinal-accessory nucleus (*t*), and connected with numerous nerve-cells. As the slender longitudinal column ascends the medulla to *n*, fig. 27, the transverse bundles (*n''*, dark dots) diminish in number until they are reduced to a comparatively few fibres, which are seen in the transverse section (fig. 25, M, Plate X.), arching round the inner border of *n*. But in proportion as these transverse bundles diminish on the *inner* side of the slender column, the fibres proceeding from the posterior portion (AA, fig. 25, Plate X.) of the spinal-accessory nucleus sweep forward round it on its *outer* side, in company with other fibres coming from the posterior pyramid. In fig. 8, Plate

VIII. these arciform fibres are seen between n and N. They pass between the separated longitudinal bundles n''' of fig. 27, Plate X., where their cut ends are represented by the dark dots, and between other transverse fibres proceeding outwards from the spinal-accessory nucleus; and this kind of plexus through which they pass contains numerous nerve-cells whose processes are continuous with the different sets of fibres.

The next or internal layer ($t\,t$) of fig. 27, Plate X. is the spinal-accessory nucleus or tract, the cells having been omitted to avoid obscuring the fibres. It has been already stated that a multitude of these fibres run longitudinally. In fig. 25, Plate X. it has been shown that a vast number run transversely outward, from G to the slender column n and to the lateral column beyond it. In the oblique longitudinal section (fig. 27) we see both sets of fibres together. The longitudinal are not quite parallel, but intersect each other at different angles, and bend round to be continuous with the transverse. The latter then run outward, between the *other* set of transverse *arciform* bundles (n'', fig. 27, dark dots) (and n, fig. 5, Plate VIII.), which cross them at right angles as they sweep round from behind forward to the anterior pyramid. On reaching the slender column (n, fig. 27, Plate X.) some of them run with it longitudinally; but by far the greater number, frequently in bundles, continue their course outward, and cross it more or less at right angles to enter the layer $n'\,n'''$, where they contribute to form the grey network between the longitudinal and the outer *transverse arciform* bundles. With the former of these bundles (n''', fig. 27, Plate X.) some of them are directly continuous; and with the latter (represented by the dots at n'') others appear to be connected through the medium of the intervening cells: the rest continue outward across the fine longitudinal fibres of the next layer, d', where similar connexions with the cells and longitudinal fibres appear to take place; some of them reaching the superficial white column d, in which they become lost.

The course and arrangement of the different sets of fibres in this extremely complicated structure may now perhaps be more completely understood, if we suppose the longitudinal section (fig. 27) to be applied with its plane perpendicular to the planes of the transverse sections (fig. 8 & fig. 5, Plate VIII.), so that the *upper* border (t) of fig. 27 shall coincide with the line L t of fig. 8, and its *lower* border (L t) with the same line in fig. 5.

In descending the medulla below fig. 5, Plate VIII., the innermost fibres (n') of the layer d' (fig. 27, Plate X.), in which the slender column n terminates, become still further removed from the central nucleus (t) of the spinal-accessory nerve, by the interposition of lateral grey substance, with which the lower roots of this nerve are connected, the cells of the central nucleus behind the canal being now small and sparing in number. Fig. 28, Plate X. represents the left lateral half of the grey substance of the medulla between figs. 4 & 5, Plate VIII. The central nuclei of the spinal-accessory and hypoglossal nerves (t, t') are only just marked out around the canal, while the lateral grey substance beyond them is crossed by portions of the remaining curved bundles proceeding from the restiform and postpyramidal nuclei to the decussation of the pyramids, which have ceased to derive their fibres from the *lateral* columns, that part of those columns

from which these fibres *were* derived being now occupied by the beautiful network d' d', fig. 28, Plate X., containing in its meshes the longitudinal bundles which are continuous with the layer d' n', at the lower border of fig. 27, Plate X. The innermost of these bundles (n'), in which the slender column (n) terminates, are, in fig. 28, Plate X., situated at the extremity of the line n; and at this point the lower rootlets of the spinal-accessory nerve (r) are connected with the border of the lateral grey substance. Some of the fibres of these rootlets turn backward round the little network of fibres (e), mixed with cells, joining the lateral grey substance to the grey tubercle or caput cornu posterioris, and seem to be connected with it; while others turn forward toward the remains of the anterior cornu (f')*. Still further down these anterior roots of the spinal-accessory nerve may be traced to the anterior horn of the spinal cord, as far forward as the group of cells from which the anterior roots of the spinal nerves take their origin, as may be seen in fig. 29, Plate X., which represents a transverse section of the grey substance of the spinal cord at the lower part of the first cervical nerves†. r indicates three branches of the spinal-accessory nerve of the left side, proceeding to the lateral grey substance, and thence forward to the side of the group of cells in the anterior horn. e is the caput cornu or dilated extremity of the posterior horn; e'' indicates the posterior nerve-roots first passing transversely through the posterior white column immediately behind the caput cornu, and then crossing the cervix cornu to the lateral grey substance with which the spinal-accessory nerve is connected, and which they separate from the central grey substance (t). At the same part of the lateral grey substance we see the origin of some of the decussating bundles (f'') which form the point or termination of the anterior pyramids, and which frequently *seem* to be continuous with the posterior nerve-roots (e''). The spinal-accessory nerve appears to be connected with the lateral grey substance all along its border from before backward, within the curved line of the lateral column d', into which the greater number of the decussating fibres of the pyramids pass (see figs. 2, 3, & 4, Plate VIII.). The connexion of the anterior pyramids with this part of the grey substance is exceedingly interesting in reference to the influence of the will on the respiratory movements.

(16) The slender longitudinal column n (figs. 25 & 27, Plate X.) has the same kind of important connexions with the vagal and glossopharyngeal nuclei as those which it has been shown to form with the spinal-accessory; but it has moreover a direct and especial connexion with the glossopharyngeal *nerve*. While the spinal-accessory and vagus nerves enter their nuclei on the *inner side* of the slender column, although they are connected with it, many of the fibres of the glossopharyngeal nerve pass directly into it. Fig. 30, Plate X. represents an oblique longitudinal section of the human medulla in the plane of the glossopharyngeal nerve, and passing through the slender column n n and the glossopharyngeal nucleus t''. Some of the roots of the nerve (g) are distinctly seen to enter the slender column (n) and run with it *down* the medulla.

* See my Memoir "On the Medulla Oblongata," figs. 19 & 23, Phil. Trans. 1858.

† See my "Further Researches on the grey substance of the Spinal Cord," fig. 12, Phil. Trans. 1859.

(17) It has been shown that the *upper* roots of the spinal-accessory nerve arise from a special nucleus in the medulla oblongata, behind the canal, and that the *lower* roots have their origin in the lateral grey substance and anterior cornu of the spinal cord. It is an interesting fact that the hypoglossal nerve has a similar kind of double origin. Its *lower* roots arise from the upper remains of the anterior cornu, as I formerly showed in the Sheep*, and as may now be seen in Man (fig. 28 *x*, Plate X.). Here the central nucleus t', which gives origin to the *upper* roots, is only just marked out and contains only a few small cells; while the remains of the anterior cornu (f') contain two little groups of large multipolar cells in connexion with the *lower* roots *x*.

(18) In fig. 25, Plate X., J is an exact representation of the central nucleus of the *upper* roots of the hypoglossal nerve in Man, a little below the level of the calamus scriptorius, and on a level with the *upper* roots of the spinal-accessory nerve (*r*). It consists of a group of multipolar cells, which are larger, more varied in shape than those of the spinal-accessory nucleus, and resemble in every respect those of the anterior cornu of the spinal cord. These cells send their processes in different directions, and many of them are elongated longitudinally in connexion with fibres running in the same direction. There is no actual line of separation between this group and the oval group (H, fig. 25) belonging to the spinal-accessory nucleus, for each passes gradually, as it were, into the other by means of more sparingly scattered cells and nuclei which occupy the intervening space, exactly as is represented in the figure. In this intervening space some fine fibres may be seen passing from one nucleus to the other as well as from within outward; but at a higher level in the medulla I discovered a more intimate and important communication between the two nuclei, by means of nerve-processes and fibres, which will be described further on. At the anterior part of the hypoglossal nucleus, just where the nerves enter it, there is a little separate group composed of smaller cells than the others, and from which several large bands of commissural fibres proceed to the raphè, where they decussate with those of the opposite side (see J′, fig. 25). This little group is most conspicuous at a higher level of the medulla, above the calamus scriptorius, where the other cells of the nucleus are also imperfectly divided into separate groups (see fig. 32 J′, Plate XI.). There is also a remarkable fan-shaped set of commissure fibres (J″, fig. 25, Plate X.), which, arising from different parts of the hypoglossal nucleus, converge inward and forward to the raphè (F), where, like the others, they decussate their fellows of the opposite side. More externally, the roots of the nerves (*x*) are crossed, as already described, by numerous arciform fibres (M, A A) which proceed from the spinal-accessory nucleus and the slender column (*n*) adjoining. In animals these fibres are exceedingly numerous.

(19) In the Sheep, as I formerly stated, a few of the roots of the hypoglossal nerves (*x*) join these commissural fibres and cross the raphè; and in Man a few of the *higher* roots take the same course; but almost all of them enter the nucleus without decussating across the raphè. They traverse it from before backward and in other directions,

* See "Medulla Oblongata," Philosophical Transactions, 1858, fig. 13 *z*, Plate XII.

crossing the fan-shaped set of commissural fibres and reaching as far as the scattered cells intervening between it and the spinal-accessory nucleus. The lateral roots completely inclose the group of cells, those on the outer side curving inward, and those on the inner side taking an opposite course. The latter often approach the raphè at L′ so closely that they might easily be supposed to cross it; but they may always be traced outward and backward as far as a separate but small group of cells (K′) lying nearer the side and lower border of the canal. This little group or column contains numerous longitudinal fibres, and is composed of much smaller cells than those of the hypoglossal nucleus. At this level of the medulla it is in some sections scarcely perceptible, but it increases in size as it ascends, and is a structure of great importance; for I shall presently show that it forms the lower end of the column of cells and fibres which constitute the fasciculus teres, and part of the nucleus of the facial nerve. We have here, then, a most interesting communication between the facial nerve and even the *lower* roots of the hypoglossal. Still further back and nearer the canal is another very small group of nuclei, the use of which I have not ascertained.

(20) For some distance around the canal there is a dense layer of exceedingly fine nucleated fibres, which decussate each other both behind and in front (L′), and run down the raphè towards F. Further out from the side of the canal they are joined by similar fibres which proceed from the oval group of the spinal-accessory nucleus (H), and from the little group (K′) belonging to the facial nucleus. In the Ox, Sheep, Rabbit, &c., all these fibres are more conspicuous than in Man. They are crossed at right angles by a multitude of longitudinal fibres of a similar nature, which form a layer that is denser in proportion as it approaches the border of the canal.

(21) I have already stated that fine fibres run between the hypoglossal and spinal-accessory nuclei. At a higher level of the medulla I discovered a still more intimate and a most important connexion between these parts. It can only be properly seen in a longitudinal and horizontal section made at the point of the calamus scriptorius and carried up through the middle of the hypoglossal and spinal-accessory nuclei; for the fibres arch upward, and are therefore more or less divided in a transverse section. Fig. 31, Plate X. represents such a longitudinal section; and fig. 32, Plate XI. a transverse section of the parts of these nuclei left after the longitudinal section was made, so that the line of section J, H, H′ corresponds to the lower edge J, H, H′ of fig. 31, Plate X.; where J is the hypoglossal nucleus, and H the group of cells forming the anterior projecting horn of the spinal-accessory and vagus nucleus, on the inner side of the slender column *n*, where the nerve *r* enters. In the hypoglossal nucleus (J′, J″, fig. 31, Plate X.) a number of cells send their processes laterally outward in an arched direction to the inner or anterior horn (H) of the spinal-accessory nucleus; and from this, in return, elongated cells send their processes inward to the hypoglossal nucleus (J″). The majority of the cells of the anterior horn (H) of the spinal-accessory nucleus are elongated longitudinally with a multitude of fibres, and some of the transverse fibres coming from the hypoglossal nucleus (J″) cross these to the outer part of the spinal-accessory nucleus (H′), and thence to the slender column *n*.

(22) But besides this most intimate and important connexion between the two nuclei —the hypoglossal and the spinal-accessory—through the medium of their *cells*, the spinal-accessory *nerve*, as I formerly showed on several occasions, has a separate origin from the *hypoglossal* nucleus; and I also showed that both the vagus and glossopharyngeal nerves have each a separate origin from the same source. These interesting facts have been fully confirmed by Dr. JOHN DEAN, of Boston, U. S.*. In birds this separate origin of the vagus nerve from the hypoglossal nucleus is so striking, that in well-made preparations it may be seen almost at a glance†. In fishes I have recently discovered a beautiful and peculiarly interesting illustration of the same anatomical fact. In these animals there is no *separate* hypoglossal nerve, but the tongue is supplied by a branch of the *vagus*. Now I was very desirous of knowing what was the nature of the vagal nucleus in these animals, and of ascertaining whether it was a double or compound nucleus consisting of the vagal and hypoglossal nuclei joined together. On examination I found that the lower division of the vagus nerve, after proceeding transversely through the lateral part of the medulla, bifurcates into two distinct roots of considerable size; and that while one of these curves backward to spread into the grey substance behind the canal, the other bends forward into a round or oval nucleus, which, in regard both to the character of its cells and its position in front and at the side of the canal, corresponds exactly to the hypoglossal nucleus of the higher vertebrata. These appearances are so well marked,—this anterior nucleus is so distinct, and its connexion with the corresponding root of the vagus nerve is so evident,—that in well-made preparations they may be seen with the greatest facility. In fishes the roots of the vagus external to the medulla consist of two sets,—the one a little above the other. The lower set are on a level with the calamus scriptorius; the upper set are on a level with the large vagal eminence of grey substance which rests on the floor of the fourth ventricle beneath the cerebellum. Fig. 33, Plate XI. represents a transverse section of the medulla oblongata of the Cod at the point of the calamus scriptorius, just where the canal (6) opens into the fourth ventricle, and therefore on a level with the lower set of vagal nerves (14). The anterior portion of the medulla, 1, 1, 2, 3 (see left side of figure), on either side, consists of some nerve-cells, and a network of fibres and blood-vessels containing in its meshes a multitude of longitudinal bundles of different sizes. Many of these bundles are exceedingly large, particularly along the inner side next the raphè, —as represented by the round or oval spaces (1,1),—and in front at 2, where they appear to correspond to the anterior pyramids of the higher vertebrata. The nerve-cells are of considerable size, and chiefly collected into a small group (3) near the centre. Behind the two lateral halves of this anterior portion of the medulla, and lodged in a depression between them, are two other larger longitudinal bundles of fibres (4); and immediately behind these are two oval and still larger longitudinal columns of nerve-cells (5), which have precisely the same position at the side, and in front, of the canal

* On the Grey Substance of the Medulla Oblongata and Trapezium. By JOHN DEAN, M.D., 1864, pages 27, 28.

† See my Memoir on the Medulla Oblongata, Philosophical Transactions, 1858, Plate XIII. fig. 18.

as have the longitudinal columns of cells constituting the nuclei of the hypoglossal nerves in the higher vertebrata. Under a magnifying-power of about 100 diameters, a transverse section of one of these columns has the appearance represented in fig. 34, Plate XI. The cells are large and multipolar, resembling those of the hypoglossal nucleus. Between them are numerous longitudinal fibres represented by the dots; and from all parts of the nucleus a number of fibres radiate transversely toward the surface (see also fig. 33, 7, on left side), where they bend round and become lost, for there is no nerve attached to this part of the medulla. From this nucleus the *anterior* roots of the lower set of vagal nerves take their origin, and curving outward and backward in a thick compact bundle (8, fig. 33) join the *posterior* roots (9), which are somewhat more numerous, and arise from a large column of grey substance (10, 10) behind and at the side of the canal (6). This substance is finely granular, and contains a multitude of very small cells or nuclei. It sends numerous fibres into the anterior nucleus (5, see left side of figure), as well as others which, in company with those issuing from the nucleus, proceed outward to the surface at 7. On the outer side of the posterior nucleus (10) is the restiform body (11) containing some grey substance (12), from which numerous fibres converge into a large bundle (13) that runs forward and inward to decussate with its fellow across the raphè in front of the canal, and terminate on the opposite side in the anterior part of the medulla close to the group of cells (3). The correspondence of the anterior nucleus (5) and of the anterior vagus-roots (8) in the Fish, with the hypoglossal nucleus and hypoglossal nerve in the higher vertebrata, is very striking. The arrangement in the Fish is such that the fibres distributed to the tongue, instead of running forward across the medulla in the course of the dotted line x as a separate and special hypoglossal nerve, are thrown backward and aside at 8 to join the vagus and be distributed to the tongue as one of the branches of that nerve*.

(23) *Of the Olivary bodies.*—In my memoir on the Medulla, I gave a detailed account of the general appearance and structure of the olivary bodies in Man, in the Ape, in many of the Mammalia, and in Birds, and I have now only a few more observations to make on the subject. In fishes I have never been able to discover any structures to which I could point as the representatives of the olivary bodies of the higher animals. In Birds, however, they certainly exist, although their cells are not arranged in the form of a lamina, but are scattered about the column in which they are contained. In the higher Mammalia, however, they assume the form of a lamina, which, in the

* In *reptiles*, also, the vagus sends a considerable branch to the tongue, and indeed is the only nerve that supplies that organ. This branch must not be regarded as the glossopharyngeal, for it supplies not only the muscular tissue of the tongue, but the muscles which protrude and retract that organ. "La huitième paire," says DESMOULINS, "est le seul nerf distribué aux muscles de la langue et de la glotte" (*Systèmes Nerveux*, tom. ii. p. 455). I have not examined the origin of the vagus in reptiles, but probably it is similar to that which I have discovered in fishes. The spinal-accessory, also, in reptiles and birds is only a part of the vagus, which, according to BISCHOFF, gives one branch, or several branches, to the neck. In reptiles and fishes, both the hypoglossal and spinal-accessory are only branches of the vagus, or rather the three nerves form one common system.

feline tribe especially, is bent into a simple curve or loop. Fig. 35, Plate XI. represents a transverse section of the right anterior pyramid and olivary body of the Cat. On the outer side of the pyramid (*y*) is the olivary body, which consists of three masses of cells, the one in the middle (W) being a *simple* loop. Now in ascending the animal scale, I found that in the common Ape the olivary bodies are not only much increased in size and more prominent on the surface of the medulla, but that the loops or folds of the lamina, which are *simple* in the highest Carnivora, as the Cat, become thrown into *secondary loops* or convolutions, as at *w*, fig. 23, Plate X. Still higher in the scale the convolutions of the lamina are more numerous, and the bulk of the entire organ is much greater, as may be seen in figs. 36 & 37, Plate XI. The latter figure represents the right anterior pyramid (*y*) and olivary body (W) of a young Orang Outang*. Fig. 36 was drawn from a transverse section of a piece of medulla given to me by the late Mr. QUECKETT, of the Royal College of Surgeons. From the strong resemblance of this medulla to that of Man, and the large size of the olivary bodies, it evidently belonged to one of the higher Simiadæ. The olivary body itself closely resembles that of the Orang Outang (fig. 37); but it seems to be imbedded in the anterior pyramid, instead of lying behind and on its outer side. Moreover, there is another peculiarity in the existence of a large separate column (*d*) forming part of the lateral column. In both this medulla and that of the Orang Outang (fig. 37), the convolutions of the olivary lamina are as numerous as in Man, and form a striking contrast to the *simple* loop of the Cat at W, fig. 35. On a former occasion I showed that in Mammalia generally the hypoglossal nerves are attached on the *outer* side of the olivary bodies, instead of on the *inner* side, as in Man. It is somewhat curious that in all the Apes, even in the Orang Outang and Chimpanzee, their point of attachment is intermediate, that is to say, they are attached to the olivary bodies themselves.

I shall now proceed to describe the structures forming the upper part of the fourth ventricle.

* For the medulla oblongata, pons Varolii, and part of the cerebellum and cerebral convolutions of the Orang Outang, I am indebted to the kindness of Dr. MUIR, of the Zoological Gardens.

CHAPTER II.

(24) The little column of cells and longitudinal fibres seen at K′, fig. 25, Plate X., lying at the side of the central canal and immediately behind the hypoglossal nucleus (J), increases in size as it ascends the medulla to constitute the so-called "*fasciculus teres.*" Above the *calamus scriptorius*, on the floor of the fourth ventricle, it increases most rapidly, and rather suddenly, just in proportion to the *decrease* of the *hypoglossal* nucleus. Fig. 38, Plate XI. represents a transverse section of the floor of the ventricle at this level, on the left of the median line. J is the hypoglossal nucleus considerably diminished in size. Behind and overlying it is the "*fasciculus teres*" (K′), much *increased* in size, in consequence of the greater number of both the fibres and cells which it contains, the fibres for the most part forming a layer nearer its posterior surface. It is an oval or pyriform mass, and lies with its longer axis transversely inward and outward. On its inner side it tapers over the back of the hypoglossal nucleus, to join a small oval group of closely aggregated cells (T), which now makes its appearance along each border of the raphè; and on the outer side it tapers under, or in front of, the oval group of cells (H) forming the inner portion of the vagal nucleus, which partly overlies it. Some of the fibres of the vagus *nerve* (*g*) appear to be connected with it, as they run along its lower border to the hypoglossal nucleus. The outer portion of the vagal nucleus is at *t*, and the slender longitudinal column at *n*.

(25) A transverse section of the floor of the fourth ventricle a little higher up (on a level with the roots of the glossopharyngeal nerve) is represented in fig. 39, Plate XI. Here we find that the hypoglossal nucleus has almost wholly disappeared, only a few small cells (J, J′), belonging apparently to the anterior group, remaining in company with a few commissural fibres and nerve-roots (*x*). The dark oval group of nuclei (T) is much larger than in the preceding section, and on its outer side, on the surface of the ventricle, is the cut end of one of the *striæ medullares* (T′). The "*fasciculus teres*" (K′) has nearly doubled its size, and is connected by a curved band of fibres with the posterior nucleus (*i*) of the auditory nerve; *t* is the outer portion of the glossopharyngeal nucleus. It is much smaller than the corresponding part of the vagal nucleus (fig. 38), and has diminished in proportion as the auditory nucleus (*i*) has enlarged. On the right of *t*, the group of cells constituting the inner nucleus of the glossopharyngeal nerve has altered a little in form, being somewhat club-shaped instead of oval.

(26) In the central part of each lateral half of the medulla, and near the inner side of the caput cornu posterioris or grey tubercle (*e*, fig. 10, Plate VIII.), there is a peculiar group of large multipolar cells (U), precisely similar in appearance to those in the anterior cornu of the spinal cord. This is the lower part of a longitudinal column of cells, constituting the nucleus of the lesser root of the trigeminal or fifth cerebral nerve. Higher up in the medulla, on a level with the auditory nerve, it was pointed out by STILLING; but I have traced it much lower down—sometimes nearly as low as the level

of the inferior ends of the olivary body*. On a level with the glossopharyngeal nerve it forms a group of considerable size (U, fig. 39, Plate XI.). Its cells are lodged in the interspaces between the deep arciform and the longitudinal bundles of fibres already described (§ 15), and may frequently be seen to curve round or embrace the latter, with which some of their processes are continuous. By this continuity of their processes with the longitudinal bundles they probably establish connexions with other cells at different lengths of the column; and by a similar continuity with the transverse arciform fibres, which freely communicate with each other, and decussate their fellows on the opposite half of the medulla, they are brought into connexion with parts on either side. In some sections the cells are especially elongated forwards and backwards, as shown at U, fig. 39, and send their processes chiefly in both these directions. The processes which extend forward, but which are not shown in the figure, sometimes form a kind of tapering brush or tail of fibres in connexion with more scattered cells lying along their course, and may frequently be seen to communicate with the transverse bundles which traverse the *grey tubercle* (*e*, fig. 10, Plate VIII.), and the sensory roots of the fifth nerve contained therein. By means of a special set of commissural fibres (U′, fig. 39, Plate XI.), the entire group has a very intimate connexion with other surrounding parts, but particularly with the cells on the right of *t*, belonging to the glossopharyngeal nucleus, and with the so-called "fasciculus teres." On proceeding from the group backward, some of these fibres (at U′) turn round at different depths to end in the transverse arciform bundles; some turn round to be continuous with the longitudinal bundles; others pass further backward to the glossopharyngeal nucleus and "fasciculus teres;" while a few are seen to be continuous with returning fibres of the glossopharyngeal nerve which do not enter their nucleus.

(27) In 1857† I pointed out the fact that the descending portion of the posterior root of the fifth nerve, instead of traversing the *restiform body*, as it was previously believed to do, runs down through the front of the grey tubercle, or caput cornu posterioris. The transversely cut ends of its longitudinal fibres are represented by the dark spots in the grey tubercle at *e*, fig. 10, Plate VIII. Moreover, I formerly showed‡ that both the vagus and glossopharyngeal nerve, on their way to their nuclei, traverse the grey tubercle and pass through this portion of the fifth nerve; while I have since had reason to think that some of their roots terminate in the grey tubercle as one of their centres of origin.

* SCHRÖDER VAN DER KOLK, who did not recognize this group of cells, says that STILLING has mistaken the antero-lateral nucleus for it. This is quite a mistake on the part of SCHRÖDER VAN DER KOLK, who has himself mistaken the antero-lateral nucleus for what STILLING really means. STILLING was not acquainted with the antero-lateral nucleus, which I first pointed out in 1857, and which was subsequently more fully and well described by Dr. JOHN DEAN, who gave it that name. The two groups are perfectly distinct, as may be seen in fig. 10, Plate VIII., where *s* is the antero-lateral nucleus, and U the nucleus of the motor root of the fifth nerve.

† "Medulla Oblongata," read June 1857, Philosophical Transactions, 1858.

‡ Philosophical Transactions, 1858.

(28) This intimate connexion of the *sensory* division of the fifth nerve with the vagus and glossopharyngeal nerves in the grey tubercle, as well as the connexion, just shown, of its *motor* nucleus with the glossopharyngeal nucleus, with the returning fibres of the glossopharyngeal nerve, and with the "fasciculus teres," are facts of uncommon interest.

(29) The longitudinal fibres (V V′, fig. 8, Plate VIII.) immediately in front, and on the outer side, of the hypoglossal nucleus (t') have the same kind of anatomical connexion with that nucleus as the antero-lateral white columns of the spinal cord have with its anterior horn. In longitudinal sections carried through these columns and the hypoglossal nucleus the fibres along the border of the nucleus may be seen to enter or issue from it, just as the fibres of the antero-lateral columns do along the border of the grey substance in the cord. It has been seen that along the line L t, from the spinal-accessory nucleus outward, the longitudinal bundles between N and n are sparing and wide apart (see n''', fig. 27, Plate X.). In front of this line, however, on the outer side of the hypoglossal nucleus, and of the root of the hypoglossal nerve, at V′, fig. 8, on the opposite half the medulla, the longitudinal bundles are numerous and close together, but as in the former case, their fibres are finer than those of the white column at the surface. The smaller column (V) immediately *in front* of the hypoglossal nucleus, and between the raphè and the origin of the nerve, contains many coarser fibres than those just mentioned. Now this column, as far forward at least as the posterior part of the olivary body, is the remains of the anterior column of the spinal cord, left on the outer side of the decussating fibres of the anterior pyramid, and known as the non-decussating portion of that body. It is seen at V in figs. 2, 3, 4, 5 & 6, Plate VIII. In fig. 5, Plate VIII. this column on each side is pushed to the back of the pyramid (y), and separated from its fellow by the numerous decussating bundles (n'') which sweep round from the bases of the *posterior* pyramids and restiform bodies. In fig. 6, Plate VIII. the two columns (V) are brought more closely together, more in front of the hypoglossal nuclei; and the decussating bundles of arciform fibres (which are now wider apart), instead of separating them from these nuclei, cross them transversely and then run forward between them to the back of the *anterior* pyramids and lower ends of the olivary bodies. In fig. 8, Plate VIII. they have lost their definite outline, being fused with other longitudinal fibres at the back of the anterior pyramids, between the decussating commissure of the olivary bodies; and they are still closer together, being separated only by the central raphè, and bounded on their outer sides by the hypoglossal nerves. The anterior cornu (f', fig. 4, Plate VIII.) of the spinal cord is in fig. 5 resolved into network enclosing longitudinal bundles, and blending with the network (s) further back, which is left after the lateral columns have crossed over to the anterior pyramids (see n, fig. 28, Plate X.). In its place at f', fig. 5, Plate VIII. is developed the olivary body (W, fig. 6), which is moreover connected with the white substance of the anterior column at its surface. After the bundles from the lateral columns have crossed over to the anterior pyramids, the central part of each lateral half of the medulla (at the letter U, figs. 6, 9 & 10, Plate VIII.) contain, as I have already stated, a multitude of

longitudinal bundles. How many of these fibres belong to those portions of the lateral columns of the cord that have not contributed to the formation of the pyramids, it is not easy to determine; but it is certain that the greater number of them are new and finer fibres, arising from the grey substance of the medulla. Nearer the surface, however, and more anteriorly, the original and coarser fibres of the antero-lateral columns of the cord continue to ascend the medulla (*d*, figs. 4, 5, 6, 8, Plate VIII., and fig. 27, Plate X.). SCHRÖDER VAN DER KOLK believed that some of the original fibres of the lateral columns of the cord ascend on the same side beyond the decussation, but that they terminate, at the vagal nucleus, in the slender longitudinal column *n*, figs. 25 & 27, Plate X.* This opinion, as will be readily seen, must be erroneous; for it is very uncertain whether the slender column (*n*) contains any of the original fibres of the lateral columns; and even if it does, it is merely an offset from the layer *d'* (fig. 27, Plate X.), which continues to ascend much beyond its point of divergence (*n'*), and, as I have shown, consists, chiefly, at least, of new and finer fibres; while at the same time the superficial and original fibres of the lateral columns (*d*, fig. 27, Plate X.), like the layer *d'*, continue their course upward much beyond the point of divergence (*n'*) of the slender longitudinal column.

(30) I have already shown that the little group of small cells (T, fig. 38, Plate XI.) which lies on the inner side of the hypoglossal nucleus (J), increases as it ascends the medulla. In fig. 39, Plate XI., just where the hypoglossal nucleus ends, it is much larger, is nearer the surface, and together with the outer column K', constitutes the "*fasciculus teres*," or longitudinal column which runs along the fourth ventricle on each side of the median line. Near the level of the auditory nerves this small and inner group (T) sometimes lies with its long axis more vertical, as in fig. 40, Plate XI., and therefore forms a slightly prominent column which borders the side of the median sulcus, while the outer column (K') is more divergent, and runs along the inner side of the auditory nucleus (*i*), to reach the digital fossa of the ventricle. It will be seen that in fig. 40 this outer portion (K') of the "*fasciculus teres*," as a separate column, has diminished in size, while it has become intimately blended with the auditory nucleus (*i*), from which, in fig. 38, it was completely separated by the interposition of the vagal nucleus (*t*, H). Amongst the commissural fibres (*y'*) which decussate across the raphè, there is a conspicuous group of large multipolar cells.

(31) *Of the Striæ Medullares.*—In the floor of the fourth ventricle of the human medulla, a variable number of white bundles, of different sizes, and composed of nerve-fibres, are seen running in several directions, but chiefly more or less transversely, from the median sulcus, over the "*fasciculus teres*" and the auditory nucleus toward the root of the auditory nerves. These bundles are known to anatomists by the name of *striæ medullares*, and have been made the subject of investigation by PICCOLOMINI, SOËMMERING, SANTORINI, PROCHASKA, RUDOLPHI, the WENZELS, GALL, SPURZHEIM, CUVIER, TREVIRANUS, BOEK, LANGENBECK, ARNOLD, SERRES, BURDACH, BERGMANN, HEUSINGER and

* SCHRÖDER VAN DER KOLK, Medulla Oblongata.

others, but more particularly by OTTO FISCHER. According to PROCHASKA and others, these *striæ* are sometimes entirely absent from the human medulla, and when they are present are wholly unconnected with the auditory nerves*. On the other hand, BURDACH, BERGMANN, HEUSINGER, and ARNOLD consider that they are directly connected, either wholly or partially, with the auditory nerves. TREVIRANUS thought that the delicacy and variety of the sense of hearing in Man are due to these fibres because they are absent in animals†. ARNOLD found that, as a rule, a large proportion of these striæ were always in connexion with the auditory nerves. According to SERRES, the sense of hearing in the child is never very acute until the striæ make their appearance‡. LONGET, MECKEL, and PROCHASKA state that they are sometimes altogether absent. In one deaf and dumb subject examined by SCHRÖDER VAN DER KOLK, they were scarcely to be found, while in another they were very fully developed.

(32) In the large number of medullæ that I have examined, I have always found these striæ present in a greater or less degree; but in every instance they differed to a certain extent both in size and direction. Sometimes they arose out of the *fasciculus teres*; sometimes out of the posterior nucleus of the auditory nerve, on the floor of the ventricle; but more frequently they sprang from the median sulcus, and from the *fasciculus teres* along its edge. Some of them crossed the ventricle transversely, either in straight lines or in curves with their convexities upward, and winding round the restiform body or the inner edge of the *flocculus*, terminated somewhat abruptly, either in the flocculus itself or in the auditory nerve. Commonly one thick bundle, below the auditory nerve, turned round the restiform body to its anterior surface, and running between it and the olive, was continued into the pons (see Z″, fig. 41, Plate XI.). This bundle is pierced by the roots of the glossopharyngeal nerve, and by the upper roots of the vagus in their course inward to their nuclei§. Some of the striæ, instead of passing transversely outward towards the auditory nerve, occasionally ran obliquely upward to the inner surface of the middle peduncle; and I have sometimes found them taking an almost longitudinal course along the floor of the ventricle, beneath the superior peduncle, toward the corpora quadrigemina.

(33) On examining a transverse section of the medulla made in the course of a large stria which ran transversely in a straight line from the auditory nerve to the median

* PROCHASKA. De structura nervorum.

† Untersuchungen über den Bau und die Funktionen des Gehirns.

‡ SERRES, Anatomie Comparée du Cerveau, tom. i. p. 424.

§ This is probably one of the bundles described by BERGMANN, ARNOLD, and OTTO FISCHER. ARNOLD thinks it is connected with the facial nerve: he says, "Gewöhnlich nimmt aber auch eine Partie der Streifen oder eine ziemlich starke *Tœnia medullaris* (tab. viii. fig. 3, *n*) welche BERGMANN den Klangstab nennt, ihre Richtung aus- und aufwärts gegen den Pedunculus cerebelli und verbindet sich mit ihm; nicht selten ziehen mehrere Streifen um die strangförmigen Korper nach aussen und unten, gehen in die Bruckenfasern, auch in die Wurzeln des *Nervus facialis* über, oder verlieren sich am obern Ende der Medulla Oblongata, in jener Grube zwischen der Brücke, den oliven und stranförmigen Korpern." OTTO FISCHER says only, "Spatium triangulare, quod inter restiforme olivareque corpus et pontem Varolii interest, iniebant."

sulcus of the ventricle, I found that on reaching the median sulcus its fibres sank into the medulla, and then ran at a right angle from *behind forward* down the corresponding lateral half of the raphè, as represented at R, fig. 42, Plate XII. On tracing the fibres from this point backward and outward, they were seen to pass through and on each side of the oval group of cells (T), constituting, as already described, the inner portion of the "*fasciculus teres*," and then to wind over the outer column (K′) of that fasciculus, and over the auditory nuclei (*i* and *c o′*) as far as Q Q′, where they were closely united to the auditory nerve (P). The restiform body (*c*) was enclosed by both the stria and the nerve. *g* represents the uppermost fibres of the glossopharyngeal nerve. Some of them in their passage beneath the restiform body (*c*) turn round to *e*, *e*, *e*, *e*, the cut ends of the descending portion of the fifth nerve in the grey tubercle or caput cornu posterioris; others go to the slender longitudinal column (*n*), and the rest to the group of cells (H), which constitutes the chief nucleus of the nerve, and is continuous with the column of cells that belongs to the vagal nucleus. U is the lower end of the column of cells forming the nucleus of the motor root of the trigeminus, and S is a network containing several large multipolar cells, with intervening longitudinal bundles of fibres, beneath the "*fasciculus teres*," and in the place where the hypoglossal nucleus ended. Fig. 40, Plate XI. represents another transverse section of the fourth ventricle a little lower down than the one just described, but passing through one of the striæ. In this case, however, the stria, instead of running in a *straight line* across the ventricle, curved downward as it approached the median sulcus, and was therefore divided obliquely at different parts of its course, as seen at Q Q′. On examining the section, and then comparing it with the cut surface of the ventricle from which it was taken, and which contained the remainder of the stria, it was not difficult to see that the fibres had different destinations. On reaching the median sulcus, the stria partially divided into two branches. One of these (at Q′) ran transversely forward through the oval group of cells (T), especially through its inner and outer sides, and then passed into the raphè as in the former case. The other branch turned longitudinally downward over and through the posterior part of the oval group (T). The cut ends of its fibres are represented by the dark spots at the extremity of the line (T) on the left side. It is most probable that these fibres, after running for different distances downward, pass, like the others, transversely forward through the vesicular column (T), and thence into the raphè.

(34) There can be no doubt whatever that many of the striæ medullares connect both the portio mollis and the auditory nucleus with other parts of the medulla and brain. Fig. 41, Plate XI. represents the side and under surface of one lateral half of the pons Varolii and medulla oblongata. W is the pons, *y* is the anterior pyramid; *w* the olivary body; X the portio dura or facial nerve; *c* the restiform body; Y the cut surface of the middle and inferior peduncles of the cerebellum; Z is the auditory nerve turned backward over the restiform body; Z′ the cut end of the fifth nerve. The large band of fibres proceeding out of the fourth ventricle, and turning round the restiform body at Z″, are seen to lie close against the roots of the auditory nerve (Z), as they pass

forward to the pons, where some of them, after running round the root of the fifth nerve (Z′) plunge into its substance, while others are lost amongst its transverse fibres at W′. Both these sets of fibres are joined by others, which also spring from the fourth ventricle, but pass *beneath* the restiform body, and emerge at Y′, decussating in their passage with the roots of the auditory nerve (Z), as represented in the figure. These fibres for the most part run toward W′, where they are often continuous with a very prominent bundle of the pons. Above the auditory nerve a few more fibres (X′) proceeding from the fourth ventricle curve round the restiform body as it turns upward, and are lost on the middle peduncle of the cerebellum. These fibres are joined by others proceeding from under the restiform body at its junction with the middle peduncle.

(35) The whole of the fourth ventricle and most of the parts that I have just been describing, are covered with a layer of columnar epithelium-cells which are shorter than those around the canal of the spinal cord, but, like them, they give off from their tapering ends a multitude of fine fibres which run in different directions through the subjacent tissue. At the lateral parts of the ventricle, the epithelium frequently assumes the form of a thicker membranous layer, which springs chiefly from the grey substance lying in the angle formed by the divergence of the vagal nucleus and the posterior pyramid, and sometimes from the vagal nucleus itself, upon which, as also shown in transverse section, there is often a small heap of epithelium-cells (fig. 21, Plate IX. t'''). After winding outward round the posterior pyramid and restiform body, the membranous layer frequently spreads over the roots of the glossopharyngeal and vagus nerves, matting or joining them firmly together. Above, it is continuous with the general epithelial layer of the ventricle, and extends over the auditory nerve and side of the flocculus. When carefully peeled off from the side of the medulla, it is found to be firmly attached to the grey substance, between the vagal nucleus and posterior pyramid, by a multitude of fibres, which are the processes of the epithelial cells, and which on removal leave a corresponding number of minute perforations, giving to the surface a finely dotted appearance*.

Of the Auditory Nuclei and Nerves.

(36) I have already described the morphological changes that take place from below upward in the formation of the nervous centres which give origin to the auditory

* The membranous layer of epithelium above described is evidently the "membrane nerveuse" described by FOVILLE as springing from the auditory nerve to spread over the whole of the ventricle and into the cerebellum. "C'est de cette membrane," he continues, "que se détache la lame nerveuse qui unit au nerf auditif le petit lobule suspendu au-dessus de lui (the flocculus); à cette membrane emanée du nerf auditif se rattache encore la lame grisâtre élevée de chaque côté du calamus scriptorius" (the vagal nucleus). He considers the *striæ medullares* as only thicker bundles of the fibres which spring from the auditory nerve and extend into this "nervous membrane." "Les tractus blancs, les tractus gris remarqués à la surface du plancher du ventricule cérébelleux et signalés comme des racines de l'auditif ou comme un ganglion de ce nerf, ne sont que des faisceaux plus forts parmi ceux qui du nerf auditif se portent à la membrane nerveuse pariétale du ventricule." FOVILLE, Traité complet de l'Anatomie, &c. du système nerveux cérébro-spinal, pp. 503, 504.

nerves. These centres on each side consist of an inner and an outer nucleus. The inner nucleus (*i*, fig. 40, Plate XI.) forms a large convex mass at the surface on each side of the fourth ventricle. Lower down in the medulla it arises by a point or angle between the pyriform nucleus of the vagus (*g*, fig. 11, Plate XI.) and the upper extremity of the posterior pyramid (*b'*) in the way already described. In transverse section it is triangular, one of its angles projecting forward into the root of the caput cornu posterioris, or grey tubercle, *e*, at the side of the slender and longitudinal column, *n* (see figs. 42, 44, Plate XII.). At the lower part of the fourth ventricle it is separated from the hypoglossal nucleus, *t'* (fig. 11, Plate IX.), by the vagal nucleus (*g*); but higher up it is continuous laterally with the "fasciculus teres," K' (fig. 40, Plate XI.), the remains of the vagal nucleus (H, fig. 42, Plate XII.) having sunk away from between them to a deeper, more anterior, and lateral part of the medulla, at the root of the grey tubercle. This inner nucleus of the auditory nerve (*i*) is thickly interspersed with nerve-cells, which are round, oval, crescentic, triangular, or otherwise irregular in shape, and of every variety in size, the largest being nearly equal to those of the anterior cornu of the spinal cord.

(37) The *outer* nucleus of the auditory nerve (*c' o*, fig. 43, Plate XII.) is in contact with the outer side of that jus tdescribed. It consists chiefly of the outer and inner grey substance or nuclei of the restiform body (*c'o*, figs. 20 & 21, Plate IX., and figs. 22 & 23, Plate X.), blended together, and with what remains of the posterior pyramid after the complete formation of the *inner* auditory nucleus. This common mass now assumes the appearance of a remarkably beautiful network composed of nerve-fibres, and enclosing in its meshes a multitude of longitudinal fasciculi, the cut ends of which are represented by the dark spots at *c'o* in fig. 23, Plate X., and fig. 43, Plate XII. The manner in which these longitudinal bundles, with the grey substance between them, are derived from the restiform and post-pyramidal nuclei, is shown in the longitudinal section of the left half of the human medulla (fig. 24, Plate X.), where *c'o*, at the upper part, is seen to be formed out of *c'*, *o* blended together at *o'*. The transverse network enclosing these longitudinal fibres is composed chiefly of bundles which proceed out of the inner auditory nucleus (*i*, fig. 23, Plate X., and 43, Plate XII.), on the outer side of which they form, on leaving it, a beautifully serrated border. The cells are of different shapes and sizes, but are very much branched, or elongated on the one hand, in the direction of the transverse fibres of the network amongst which they lie, and which their processes contribute to form; and on the other hand, in the direction of the longitudinal bundles enclosed in its meshes.

(38) From both of these nuclei (the inner and the outer) the posterior division of the auditory nerve takes its origin. Near its exit from the inner nucleus (*i*, fig. 43, Plate XII.) there is generally a gentle swelling or elevation on the surface (*i'*), which contains a number of small cells dispersed amongst its fibres. From this point it winds, as a broad convex band (P), outwards and forwards over the restiform body (*p'*). In this course it contains at first a few small cells, but as it proceeds outward the cells become larger, elongated in the dirction of the fibres, and more numerous, until, at the

under or anterior border of the restiform body, they collect into a fusiform or a somewhat triangular group within a pyriform swelling of the nerve (P′). The inner layer of the nerve is whiter and more fibrous than the rest, and is continuous with transverse fibres (p') which radiate from the restiform body around which it winds. These transverse radiating bundles (p'), which divide the longitudinal fibres of the restiform bodies into flattened bands, belong to a system of arciform fibres which sweep round in front of the grey tubercle to the antero-lateral nucleus and olivary body. They are seen also at $p'\,p''$, fig. 10, Plate VIII., and fig. 24, Plate X.

(39) A few sections higher up in the medulla, on the inner side of the ganglionic enlargement of the nerve, are several irregular clusters of fine nerve-cells (Z, fig. 44, Plate X.). They are separated from the grey tubercle (*e e*) only by the arciform fibres, just mentioned, which sweep round it from the restiform body, and they receive bands of fibres, which, like the upper roots of the glossopharyngeal nerve, arise from the slender longitudinal column (*n*), and proceed outward along the posterior surface of the grey tubercle (*e e*), in which the more or less circumscribed spaces represent the cut ends of the bundles in the descending portion of the sensitive division of the fifth nerve. At U is seen the *motor* nucleus of the same nerve, increased in dimensions and connected by fibres with the "fasciculus teres" (see fig. 46). Q Q′ (fig. 44) are the cut ends of two *lineæ transversæ*, taking an oblique course over the inner auditory nucleus (*i*) and the "fasciculus teres." The network of the outer auditory nucleus ($c'o$) tapers forward and outward, and completely overlays the grey tubercle (*e e*), with which it is moreover intimately connected (see fig. 43). The ganglionic enlargement on the auditory nerve is seen at P′.

(40) A little above this level, in transverse sections carried somewhat obliquely upward into the fourth ventricle, the *anterior* division of the auditory nerve comes into view. It consists of two portions of unequal size. The smaller portion (P″, fig. 45, Plate XII.) runs backward along the upper edge of the restiform body (*c*), with an offset from which it then crosses transversely over the superior peduncle of the cerebellum to the inferior vermiform process. In this course it is accompanied by other fibres, which form with it a kind of band of white substance (c'', fig. 45, Plate XII.). This figure represents a side view of the human pons Varolii and medulla oblongata. *c* is the restiform body, bending backward to form a kind of fan-shaped expansion. The chief portion of it enters the lateral lobe of the cerebellum, grasping, as it were, the corpus dentatum; but a smaller portion turns inward, and arching over the superior peduncle of the cerebellum, enters the superior vermiform process, in company with the auditory roots just mentioned. This band of white substance (c'') is joined by some *twisted* fibres (e') coming from beneath the fillet (f') and the corpora quadrigemina (q'). Anteriorly it is continuous with the epithelium on the surface of the superior peduncle.

(41) The other portion of the anterior division of the auditory nerve (P″, fig. 46, Plate XII.) is much larger than the one just described. It traverses the medulla as a flattened band beneath the restiform body in a direction inward, backward, and a

little upward, and contains nerve-cells of considerable size, collected generally into two or three groups, and sparingly scattered at intervals with their longer axes in the direction of the fibres. In its course it immediately overlays the grey tubercle (*e*) enclosing the descending portion of the trigeminus, and is then inserted into the network of the outer auditory nucleus (c' *o*), where it diverges into several bundles. In careful dissections and longitudinal sections, the trunk of the nerve in its passage upward and inward is seen to wind round the root of the middle peduncle of the cerebellum, where it meets and overlays the descending root of the trigeminus contained in the grey tubercle, which is itself only the downward continuation of the grey nucleus of the trigeminus. first sight the two nerves seem to form a loop with each around the inner side of the middle peduncle; but on closer examination it is found that the auditory nerve passes over the descending portion of the trigeminus and enters its own nucleus a little behind and to the inner side of the conical mass which forms the nucleus of the large root of the fifth. In its passage, however, it is very intimately connected with this nerve and the grey tubercle. In fig. 46, Plate XII., there may be observed in the middle of the grey tubercle a circular mass or column (*e*) composed of small nerve-cells. In front of this and closely connected with it is a beautiful and delicate grey network containing small nerve-cells, and enclosing in its meshes the numerous bundles of the descending root of the fifth nerve, the cut ends of which are represented by the dark masses. This network is continuous behind with the coarser one which forms the outer auditory nucleus (c' *o*), and which gives origin to the anterior division of the auditory nerve (P''). On the inner side of the grey tubercle, at U, is the group of large multipolar cells composing the nucleus of the small root of the fifth nerve, and connected by a plexus of fibres with the *fasciculus teres* (K'); and in front of this nucleus and of the grey tubercle is a broad band of arciform fibres (p'' p''') which proceed from the restiform body and middle peduncle at p', to sweep round and diverge into the central parts of the medulla. Fig. 47, Plate XII. represents a dissection of the left side of the medulla and of the fourth ventricle, showing the anatomical relations of these and other parts. The dissection was made by first removing the epithelium on the posterior pyramid and peeling off the posterior root of the auditory nerve from without inward, including the *inner* nucleus in which it ends. The restiform body or inferior peduncle (*c* c') of the cerebellum, and the middle peduncle (c'''), were then drawn gently away or aside from the central portion of the ventricle, and pressed a little downward, exposing a somewhat triangular space which is divided into two unequal parts (A', B') by the large root (C'') of the fifth nerve in its passage to the conical eminence or nucleus (D') which projects from the side of the ventricle. The descending prolongation of this nucleus with the descending portion of the nerve, constituting together the grey tubercle (*e*) of fig. 46, are seen to be overlaid by the anterior division (P'') of the auditory nerve, as it passes obliquely upward and inward to its nucleus beneath *i*, which is the concavity left by the removal of the *inner* auditory nucleus with the *posterior* division of the nerve. The anterior and under portion of the trigeminal nucleus (D'), where it is connected with the point of the fillet

(f'), gives origin to the small or motor root (G$'$) of the fifth nerve, which is separated from the large root (C$''$) by the smaller division (A$'$) of the triangular space, transmitting a small bundle of the middle peduncle coming from the pons Varolii. The larger root of the fifth nerve (C$''$) is separated from the anterior auditory nerve (P$''$) by the larger division (B$'$) of the triangular space, transmitting a corresponding portion of the middle peduncle, ascending also from the pons. At E$'$ the *superior* peduncle of the cerebellum is rolled forward, exposing a thick and broad tract of grey substance (D$''$) which extends obliquely upward beneath it from the conical nucleus (D$'$) of the fifth nerve. On the inner side of the auditory nucleus (i) is an oval mass (F$'$) imbedded in the substance of the fasciculus teres, and connected with the facial nerve.

(42) In Mammalia generally the auditory nuclei and nerves present nearly the same appearances as those which I have described in Man; but in all those animals there are one or two points of difference, and in some there are certain peculiarities which deserve notice. In all the larger Mammalia, as the Ox, Sheep, &c., the nerve-cells of the outer nucleus which gives origin to the anterior or lower root of the auditory nerve, are much superior in size to those of the human medulla. Moreover the anterior root on entering the nucleus is generally somewhat more divergent than in Man, as may be seen at P$''$, fig. 48, Plate XII., which represents the left lateral half of the medulla and part of the inferior vermiform process of the cerebellum in the Rabbit. Amongst the divergent roots are many longitudinal fibres, which are especially numerous at the bottom (e''') of the grey tubercle (e). In the same animal the *posterior* root of the nerve is very large, and is especially remarkable for the enormous convex enlargement, or ganglion on its surface, at the side of the fourth ventricle just before it enters the inner nucleus. In the Cat this remarkable ganglion is absent; but as the nerve proceeds outward it gradually swells into a large club-shaped ganglionic mass (PP$'$, fig. 49, Plate XIII.), which is crowded with nerve-cells. The inner nucleus ($c'\,o$) is largely developed, and its connexion with the inner layer (P$'''$) of the nerve, which consists chiefly of *white* fibres, is very distinct. Below the inner nucleus ($c'o$) is the descending trigeminal root (e''), which here forms a broad and compact layer of fibres on the outer side of the grey tubercle (e). On the inner side of this tubercle is the large round *antero-lateral nucleus* (s), which is connected on the one hand with the arciform fibres sweeping round from the restiform body (p', p''), and on the other hand, with its opposite fellow, by means of a broad band of commissural fibres which decussate across the raphè with those of the opposite side*.

(43) Just above the posterior root of the auditory nerve the auditory nucleus becomes closely connected with the flocculus; and at the level of the anterior root (P$''$, fig. 48, Plate XII.) the nuclei ($c'\,o$ and i) stretch backward and inward to join the side of the inferior vermiform process (I$'$ I$''$). At this part the plexus of bundles from the outer

* In the Rabbit the glossopharyngeal nucleus is very large, and the fibres which cross it from the inner auditory nucleus (see t'', fig. 24, Plate X.) are unusually numerous. On a former occasion (Phil. Trans. 1859) I pointed out the very large size of the caput cornu and grey tubercle in all the Rodentia. The grey tubercle in the Rabbit is seen at e, fig. 48, Plate XII., surrounded by the descending root of the fifth nerve (e'').

nucleus ($c' o$) runs through the commencement of the superior peduncle, or *processus è cerebello ad testem* (E′ E″), from which it extends into the vermiform process (I′ I″). The light spaces between the bundles of the plexus at E″ are the longitudinal fasciculi of the superior peduncle. The same kind of appearances are observable in the human medulla. In fig. 46, Plate XII. a plexus of fibres containing nerve-cells is seen to extend backward from the outer nucleus ($c' o$), partly toward the corpus dentatum cerebelli (J′), but chiefly, in company with other fibres from the inner nucleus (i), over the fourth ventricle to the inferior vermiform process.

(44) A brief account of the formation of the auditory nuclei and of the course and connexions of the auditory nerves was given in my "Notes" published in the 'Proceedings of the Royal Society' for June 20, 1861, and has since been confirmed by Dr. JOHN DEAN, whose descriptions are much superior to those of either STILLING or SCHRÖDER VAN DER KOLK. STILLING, however, was the first anatomist that described the course and attachment of the auditory nerve within the medulla, and his descriptions, so far as they go, are very correct, and faithfully illustrated by very beautiful engravings. But he failed to trace the *posterior* auditory root to any nucleus within the medulla; that which I have shown to be its proper nucleus, he mistook for the nucleus of the glossopharyngeal nerve*; and although he was the first to trace the *anterior* auditory root to what I have called the *outer* auditory nucleus ($c' o$), he scarcely seems to consider this as its proper origin†. STILLING had evidently not discovered the morphological changes through which, as I have shown, the auditory nuclei are developed. Moreover the bundles of longitudinal fibres which run along the front of the grey tubercle, and which I have shown to belong to the descending root of the trigeminus, were mistaken by STILLING for the primitive fasciculi of the posterior columns of the spinal cord,—" pristina pars funiculorum alborum posteriorum." SCHRÖDER VAN DER KOLK'S account of the origin and connexions of the auditory nerves, although fuller than that of STILLING and in many respects superior, is nevertheless imperfect, and in some points erroneous. Like STILLING, he had evidently not detected the important morphological transformations through which, as I have already shown, the auditory nuclei are developed, and he was certainly not acquainted with the real nature and connexions of what I have termed the *inner* nucleus. Whether, like STILLING, he mistook this nucleus for that of the glossopharyngeal nerve, is not easy to say, as he has nowhere given us any account of the origin of that nerve. Certain it is that he had not discovered the connexion of the *inner* nucleus with the true posterior root, which he evidently confounded with the *striæ medullares*‡. He corrected, however, the error which STILLING had made in describing the longitudinal fibres in front of the grey tubercle as the primitive posterior columns of the spinal cord, and showed that they consist of the descending root of the fifth cerebral nerve§.

* Ueber die Medulla Oblongata, p. 40, tab. vii.

† Pons Varolii, pp. 158, 159.

‡ Spinal Cord and Medulla Oblongata, pp. 126, 127.

§ This important anatomical fact was discovered independently by SCHRÖDER VAN DER KOLK and myself at

Of the Facial Nucleus and Nerve.

(45) The peculiar course taken by the roots of this nerve, at their origin from the floor of the fourth ventricle, as well as the intimate communications which they form with the roots of the abducens nerve, have rendered their examination so exceedingly perplexing, that although they have been carefully investigated by several eminent histologists, it is acknowledged that the question has never yet been satisfactorily settled. My own account of the course pursued by this nerve will be found to differ considerably from that of preceding anatomists, in consequence, I believe, of the different and more varied plan of investigation which I have adopted, and which has enabled me to determine, with great accuracy, the points of peculiar difficulty. I shall first describe the minute structure of the facial nucleus. This nucleus occupies the greater portion of the convex longitudinal column which runs along the floor of the fourth ventricle on each side of the median furrow, and which is well known to anatomists as the "fasciculus teres." A transverse section of this column on the left side of the ventricle, and a little below the origin of the facial nerve, in Man, is accurately represented in fig. 50, Plate XIII. Like the rest of the ventricle, it is covered with a single stratum of columnar epithelium (f''). Beneath the epithelium is a broad layer of grey substance, which is continuous with that of the opposite side, beneath the median fissure. It consists of nuclei, cells, and fibres. The nuclei, for the most part, appear to belong to the connective tissue of the layer, and are very numerous. The cells, on the contrary, are sparingly scattered, and of small size. They are larger and more numerous along the under surface of the layer, and at its lateral part, where they are frequently collected into a small group (g''). The fibres are of two kinds. Some of them, which are exceedingly fine, proceed from the tapering ends of the epithelial cells, and running through the layer in different directions, are connected in part with its nuclei. The others are connected with the nerve-cells and nerve-roots, and run both in a transverse and longitudinal direction. On the median side of the layer, at g''', the transverse fibres (which appear to consist of those derived from both the epithelium and nerve-cells) are particularly numerous, and some of them decussate in front of the median furrow (h''), with their fellows of the opposite side. Sometimes at the side of the furrow there is a very distinct oval or fusiform group of small cells, as shown on the right in the figure.

(46) Beneath the lateral and middle portions of this superficial layer of grey substance,

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almost exactly the same time. My Essay on the Medulla Oblongata, in which the statement appears, was read before the Royal Society in June 1857, and published in Part I. of the Philosophical Transactions for 1858; and SCHRÖDER VAN DER KOLK's Essay on the Medulla Oblongata, in which the same fact is stated, was also published in 1858 (see his translator's Preface). But there is some difference between SCHRÖDER VAN DER KOLK's account and my own. He considers that the whole of the grey tubercle in the upper part of the medulla consists of the descending *root* of the trigeminus, and that it differs in structnre from the grey tubercle below the olivary bodies; while I regard the grey tubercle throughout the medulla as the downward prolongation of the grey nucleus of the trigeminus, and the longitudinal bundles in front of the tubercle, as the downward prolongation of the fibres of the posterior root.

and partially blended with it, is a large and nearly cylindrical column of nerve-cells (Q″) constituting the principal nucleus of the facial nerve. The cells are much larger than those of the superjacent layer, but differ from each other considerably both in shape and size, and have a great resemblance to the cells of the hypoglossal nucleus. Their average size is smaller in Man than in the higher Mammalia, as the Sheep or Ox. From the lateral part of this nucleus bundles of curved fibres (R″) proceed outward in the direction of the facial nerve. From the middle of the nucleus other bundles of fibres (S″) extend forward to the motor nucleus of the trigeminal or fifth cerebral nerve; and on the *inner* side of the nucleus is another system of fibres (T″ T‴), extending, like the former, from behind forward, but differing among themselves with regard to their destination. Only a part of these transverse fibres, as we shall presently see, issue from the superficial grey layer (*g*‴); most of them radiate from a *longitudinal column*, which runs immediately beneath it, and which is composed of fibres of the facial and abducens nerves, but chiefly of the former. Some of them curve outward and enter the facial nucleus (Q″); while the rest extend forward, in company with those at S″ proceeding from the *middle* of the same nucleus, to reach the motor nucleus of the fifth nerve, and the *superior* olivary body*.

(47) Another set of transverse fibres (U″, U‴) crossing at right angles the three sets of fibres just described, connect the column of cells (Q″), on the one hand with the auditory nucleus (at U″), and on the other hand with the opposite side of the medulla across the median raphè at U‴.

(48) In transverse sections made a little higher up, we see the oval cut-end of a longitudinal column, from which the third set of transverse fibres (T″), just described, radiate forward. This column is represented at T″, fig. 51, Plate XIII. It first makes its appearance, however, below the level at which the nerve enters the nucleus, in sections intermediate between fig. 50 and fig. 51. In fig. 51 may be observed a number of fibres converging from different parts of the superficial grey layer at *g*‴, and turning round the oval column (T″) to decussate across the raphè, in company with others proceeding from the principal nucleus (Q″). Some of these converging fibres, however, instead of winding inward round the column to the raphè, run forward as roots of the abducens nerve (V′).

(49) In the Mammalia the facial nuclei differ in some respects from those of Man. In the Rabbit the commissural fibres are remarkably well seen. Fig. 48, Plate XII., as before stated, represents a transverse section of the left half of the medulla. A little below the entrance of the facial nerve, near the median furrow, is the cut-end of the longitudinal column (T″), which is more cylindrical than in Man. On the outer side of this is the principal nucleus of the facial nerve, included within the crescentic and dotted line. The cells of this nucleus are very numerous, but smaller than those of Man, and somewhat different in shape. On its outer side are some much larger multipolar cells, sparingly scattered, but passing uninterruptedly into the denser group constituting the

* In the Orang Outang these fibres are uncommonly numerous.

outer auditory nucleus ($c' o$), to which they seem to belong. The superficial grey layer forming the floor of the fourth ventricle is deeper than in Man, and contains larger and more numerous cells. Fig. 52, Plate XIII. represents the same parts in the Rabbit more highly magnified. The longitudinal column (T'') is closely encircled by a dense layer of fibres, which, after reaching its inner side, run for the most part together across the raphè to decussate with their fellows immediately below the median furrow (h''). In this course they are joined by other fibres proceeding from the column itself. Some of them, however, instead of crossing the raphè appear to become longitudinal at the point (h'''). Adjoining this layer of fibres, on the left or outer side of T'', and forming the chief part of the same commissural system, is a broad fan-shaped expansion of fibres, which converge inward to the front of the longitudinal column (T''), where they interlace each other in an intricate plexus ($k' k'$), between a multitude of longitudinal bundles (represented by the dark masses) with intervening multipolar cells. The greater number make their way through this plexus to the raphè to decussate with their fellows of the opposite side; while the rest, instead of running to the raphè, bend forward precisely in the direction of the abducens nerve (k''), and joining in the general plexus between longitudinal bundles and nerve-cells advance towards the front of the medulla. It is probable, however, that many of these transverse fibres communicate their influence longitudinally by means of their connexion with the numerous nerve-cells, of which some of the processes run with the longitudinal bundles and form part of their constituent fibres; for such an arrangement I have discovered in other portions of the medulla having the same general appearance. If such be the case, the interlacement of the transverse fibres, and their communication with different longitudinal bundles, provide for a wonderfully extensive and complicated commissural connexion between parts at different levels. On considering the parts from which this fan-shaped system of transverse fibres is derived, we find that some of them issue from different portions of the superficial grey layer ($g'' g'''$) with different degrees of curvature forward and inward; that others come from the neighbourhood of the auditory nucleus ($c' o$); and that many arise out of the large group of cells included in the crescentic dotted line, and constituting the principal nucleus of the facial nerve*. All the fibres derived from both g'' and $c' o$, $c' o$, run into this nucleus; but whether they all pass through it to reach the plexus or the raphè I cannot decide. It is probable that some of them, at least, are commissural between the facial nucleus and the parts from which they are derived.

Of the Facial Nerve.

(50) It was evident to me that the complicated course and connexions of the facial nerve could never be accurately ascertained by the method hitherto adopted of examining transverse sections alone. The plan pursued by myself was as follows. Having first ascertained the exact course and connexions of the nerve, as exhibited in *transverse* sections, I then carefully made a succession of longitudinal sections in planes inclining

* The cells have been omitted in order to show more plainly the fibres which pass through it.

inward in the direction of the line m', m'', fig. 51, Plate XIII. (examining by means of a lens the cut surface of the medulla after each section), until I found that I had exposed the *outer* fibres of the nerve. The remaining portion of the nerve, in its course inward to the "fasciculus teres," was then exposed by carefully taking off a succession of similar sections in planes inclining more and more horizontally inward as the "fasciculus teres" was approached, the last sections being quite horizontal, from l' to l'', fig. 56, Plate XIII., and therefore including the posterior portion of the longitudinal column (T″) lying at the side of the median furrow (h''). When this process was completed, it was found that the nerve, on reaching the fasciculus teres, bent longitudinally down the medulla, and after a very short course, again bent transversely forward, to form a loop along the side of the median furrow, as shown at q'' in the Sheep (fig. 53, Plate XIII.) and in Man (fig. 54). The summit of this curve constitutes the longitudinal bundle of fibres of which the oval cut-end in transverse sections is seen at T″, figs. 51, 52, & 56. In the Sheep the course of the nerve q'', fig. 53, through the medulla on its way to the "fasciculus teres" is nearly straight, and nearly at a right angle to the axis of the medulla; while in Man (fig. 54) its course through the medulla is not only rather serpentine or wavy, but inclines somewhat *upward*. Hence the differences of appearance between *transverse* sections in Man and those in animals. The loop which it forms reaches close up to the edge of the median furrow (h''), and encloses its nucleus (Q″), which together with it forms the oval swelling (r'') seen on the surface of the *fasciculus teres* of the opposite side. The lower arm of the loop in its course forward divides like a brush into separate fibres which plunge into the motor nucleus of the fifth nerve, and into the superior olivary body (s''). Fig. 55, Plate XIII., represents a thin section of this loop, made in the plane of its course, from Man, magnified about 100 diameters, and viewed as from the side of the medulla. $g''' g'''$ is the superficial grey layer on the surface of the *fasciculus teres*, and seen in transverse section at $l'' g'' g'''$, fig. 56, Plate XIII. The root of the facial nerve ($v''' q''$, fig. 55), just before it curves downward along the side of the median furrow, beneath the superficial grey layer, is divided into separate bundles by long but very narrow streaks of longitudinal fibres, represented by the perpendicular, dotted lines. Its uppermost fibres (at v''') run directly backward and slightly upward to a collection of small cells and nuclei (v'') lying beneath the superficial grey layer of the ventricle, which is here composed of fine longitudinal fibres and numerous oval cells. The rest of the nerve divides into two portions, composing a superficial and a deep stratum of fibres. Its superficial stratum, on reaching the grey layer, curves *downward*,—that is, to the right, and in the plane of the paper, as seen in fig. 55,—to form the loop already mentioned. Its deep stratum of fibres bends *forward*, that is, perpendicular to the plane of the paper, and not to the right, in looking at fig. 55. For the most part they directly enter the nucleus Q″, as shown at q'' Q″, fig. 56. The course of these two strata of fibres may be better understood, perhaps, by supposing fig. 56 to be turned halfway round to the right with its plane perpendicular instead of parallel to the plane of fig. 55, and so that its nerve q'' shall coincide with the nerve q''

of fig. 55. It must be understood that in fig. 55 the nucleus Q″ beneath the loop extends under the *trunk* of the nerve *q*″; and that in fig. 56 T″ is the loop cut transversely. Moreover, these two sets or strata of fibres decussate each other at the first bend of the loop; for some from the deep or anterior stratum (*q*″, fig. 56) run first *transversely* and obliquely *backward* from W″, and then *longitudinally downward*, along the *posterior* portion of the loop at U; while others from the superficial or posterior stratum (*l*′) run first *transversely* but obliquely *forward* from W‴, and then longitudinally downward along the *anterior* and *middle* portion of the loop at T″, U′, which represents a transverse section of it in the direction of the line Q‴, fig. 55. It is evident, then, that the descending fibres of the loop cannot be parallel, but must intersect each at different angles, as shown in fig. 55, Plate XIII., which represents exactly the appearances presented by a very thin slice of the loop made in the plane of its course, and magnified about 100 diameters. Some of the fibres of the superficial stratum are seen to extend *backward* to the superficial grey layer (*g*‴, fig. 56); while many of those belonging to the deep stratum (*q*″) curve *forward* into the group of cells (Q″). But the proper fibres of the nerve are evidently joined and crossed by others which proceed from the smaller group of cells (*v*″, fig. 55), and from the superjacent grey layer of the ventricle.

(51) The *lower* arm of the loop (*q*‴, fig. 55) is smaller, looser, or less sharply defined than the trunk of the nerve (*q*″), and hangs gracefully forward like a plume of feathers. Many of its fibres droop into the facial nucleus (Q″) over which the loop is formed, and which is traversed moreover by a large number of longitudinal bundles communicating with each other in the manner of a plexus.

(52) We shall now see what important light is thrown by this dissection on the otherwise inexplicable appearances presented in transverse sections. If we make a transverse section inclining somewhat upward through the medulla, in the direction of the line W″ W″, fig 55, Plate XIII., and therefore in a plane passing through the *lower* arm of the loop (*q*‴), we have the appearances presented in fig. 50, Plate XIII., which, however, is more highly magnified. In this figure we see that the set of transverse fibres (T″, T‴), of which the origin was exceedingly obscure, belong to the lower arm of the loop (*q*‴, fig. 55), and that their apparent abruptness of origin is due to the circumstance of their having been cut across at the point where they change their course from longitudinal to transverse. If we make another transverse section a little higher up, between the arms of the loop, in the direction Q″, Q‴, fig. 55, it is evident that instead of seeing the set of fibres (T″, fig. 50) which emanate abruptly from beneath the superficial grey layer (*g*‴), we shall see the transversely-cut surface of the longitudinal portion of the loop. In Man this cut surface is almost perfectly oval (T″, fig. 51, Plate XIII.), but in the Rabbit (fig. 52) and some other animals it is more circular. The positions of the cut-ends of its fibres evidently show that these fibres are not parallel; and this appearance is quite explained by the decussation along the summit of the loop, at Q‴.

(53) If a transverse section be now made along the lower side of the *trunk* of the nerve (*q*″, fig. 55, Plate XIII.), in the direction of the line *g*‴, *g*⁗, we find that its fibres,

on reaching the commencement of the loop, spread out, and bend forward and inward, but, at the same time, obliquely downward, so as to enter different parts of the nucleus by a series of drooping bundles along the under surface of the loop, as seen at the end of the line (Q'''). A transverse section along this part of the nerve is represented in fig. 51, Plate XIII. If we turn this figure on its right side with the plane of the paper perpendicular to the plane of that on which fig. 55 is represented, we shall have a good idea of the course of these fibres, provided we recollect at the same time that they run *somewhat obliquely* downward or to the right. In consequence of this downward course, the fibres of the nerve, as they enter the nucleus Q'', fig. 51, Plate XIII., are observed, in transverse sections, to be shaved off obliquely at different lengths. Moreover, it will be seen that all these fibres belonging to the *lower* side of the nerve-trunk enter different parts of the nucleus from without inward, the innermost meeting and intimately mixing with those of the abducens nerve (V'), as they bend forward on the outer side of the oval column or loop (T''). It is evident, therefore, that none of them contribute to form the longitudinal column (T''), although a few pass in front of it to decussate across the raphè with their fellows of the opposite side.

(54) On examining a similar section of the medulla a little higher up, as at v''', for instance, fig. 55, Plate XIII., we find that the nerve divides into two portions, a superficial and deep portion, as already stated, and as represented at l' q'', fig. 56. The fibres belonging to its deep portion (q'') bend forward and inward, as in the former case, and enter the nucleus (Q''), which is now somewhat diminished, and where they meet the network of bundles proceeding from the abducens nerve (V'). The fibres of the other portion, on reaching the *fasciculus teres*, curve downward without entering the nucleus, and thus contribute to form the longitudinal part or summit of the loop, the transversely-cut end of which is shown at T''. In the transverse section, therefore (fig. 56), they are seen to enter the cut-end of this longitudinal part (T''). Before they enter it, however, their arrangement, as already stated, is very curious, and doubtless very important. Many of the fibres from the deep or *anterior layer* (q'') of the nerve are seen to run obliquely *backward* and inward to the *posterior* or upper layer (V) of the longitudinal column (T''), where they bend round and run downward; while the fibres forming the superficial or *posterior* layer (l') of the nerve run obliquely *forward* and inward to enter the middle and anterior layers (T'' V') of the longitudinal column, and run downward with it, like the others. Some of them, however, continue their course transversely in front of the column to decussate with their fellows of the opposite side, across the median raphè (at h). It is evident, therefore, that just before these two sets of fibres bend round and contribute to form the longitudinal portion of the loop, they decussate each other (as shown in fig. 56, W'' W''') immediately behind the facial nucleus (Q''), with which the fibres forming the deep or anterior layer of the nerve are connected*. This, however,

* This decussation is crossed nearly at right angles by roots of the abducens nerve proceeding to the superficial grey layer (g'', g'''), and by other fibres which proceed from this layer to the nucleus (Q''), and which are particularly numerous in the Rabbit, Sheep, and other animals.

although the principal, is not the only, nucleus of the facial nerve; for some of the superficial or posterior fibres, as represented in fig. 56, may be traced backward and inward to the superficial grey layer (g''', g'') of the *fasciculus teres*, and especially to a group of cells (g''') situated on its outer side. Behind this group are the cut-ends of three considerable blood-vessels enveloped in their sheaths. The trunk of the nerve (q'') is frequently separated into two portions by a long and broad streak of grey substance (q''') containing some nuclei or small cells and the branches of a blood-vessel, and behind these the fibres are again separated by long and narrow streaks of longitudinal fibres, represented by the dotted tracts.

(55) In transverse sections of the medulla made along the uppermost border of the facial nerve, almost all traces of the principal nucleus disappear, and almost all the fibres of the nerve may be seen to enter the longitudinal portion of the loop (T$''$, fig. 56, Plate XIII.). Of those that run inward along the front of this portion of the loop, some turn backward to enter it (at V$'$), while others pass onward to decussate across the raphè (at h), the rest appearing to stop at its inner side (h''', fig. 52), at the edge of the median furrow, where they seem to become longitudinal, amongst the cut-ends of a layer of longitudinal fibres. The fibres of the nerve which pass round the *posterior* surface (T$''$, fig. 56), all enter it in succession, none of them reaching the raphè, or even so far as the inner side of T$''$, but terminating in it about the point l''; so that it is not even enclosed by fibres of the nerve.

Some of these uppermost fibres of the facial nerve, however, instead of running down with the longitudinal portion of the loop, diverge somewhat upward and backward amongst an irregular group of smaller cells and nuclei (as represented at v'', fig. 55) lying beneath the surface of the fourth ventricle.

(56) Such is the remarkable and complicated course of the roots of this importamt nerve. The accounts which Stilling and Schröder van der Kolk have given of the origin of the facial are very imperfect, and contain serious errors. Stilling, however, has the merit of discovering that the lower fibres of the nerve arise from the large nucleus of multipolar cells. Higher up the fibres appeared to him to run inward to the raphè, without entering the nucleus, and to decussate with their fellows of the opposide side. In this course they enclose in front and behind, but do not *enter* the longitudinal column, which I have shown to be the longitudinal portion of the loop of the facial nerve itself. This column is considered by him to be what he calls "the *constant* root of the trigeminus" or fifth cerebral nerve. At the upper limit of the nerve he found that all traces of the nucleus had disappeared; but he thought that the fibres bend downward to the nucleus below, while the rest run through the raphè to the columns which he considers as prolongations of the anterior columns of the spinal cord. Upon these points, however, he speaks with some diffidence*.

(57) Schröder van der Kolk's account is exceedingly defective, being scarcely more than "a general assent to the description of the course of the facial nerve given by

* Stilling, Pons Varolii, pp. 37, 38, plates 3, 4 & 5.

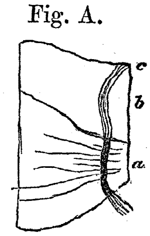
STILLING"*, with this exception, however, that he fell into a still more extraordinary blunder than STILLING, by asserting that the longitudinal column is not, as STILLING believes, *a root of the trigeminus*, but "*one of the cut posterior roots of the auditory nerve*" (one of the striæ medullares)†. It is remarkable that it did not occur to SCHRÖDER that bundles of fibres so variable in their course and size as the striæ medullares could not always be found in exactly the same place and present exactly the same appearances. Frequently in transverse sections the cut ends of more than one of the striæ are seen at the surface of the ventricle, and one of these, which is sometimes, but not always, situated at the side of the ventricle, was mistaken by STILLING for another root of the trigeminus, which he calls its "*inconstant* root."

(58) DEAN'S account of the origin of the facial nerve is by far the fullest and best. He states that at the upper part of the nerve, the whole bundle may be traced inwards to the longitudinal column, where the central portion of the root terminates abruptly, the outer fibres turning off behind and in front of the column, which is thus completely encircled by the roots which afterwards pass onwards to the raphè. But "even," he says, "in the upper portions of the facial course, where the whole bundle seems at first sight traceable to the raphè, the number of bundles actually decussating or passing into the raphè seems so small when compared with the great thickness of the root, that I am inclined to think that many of the fibres do actually turn downwards, passing down in the longitudinal columns on each side of the raphè to the underlying nucleus, justifying in this respect the conclusion of STILLING. I have been confirmed in this supposition, by frequently observing in the columns which STILLING has called the *constant roots of the trifacial*, and SCHRÖDER VAN DER KOLK *roots of the auditory*, great numbers of fibres obliquely cut across, which are especially noticeable in connexion with the abrupt transmission of the facial roots just at this point, and I am inclined to consider these columns as, at least, partial channels by means of which the upper portion of the facial roots are conveyed downwards, either to the underlying nucleus or to decussate below in the raphè"‡.

On the Nuclei and Roots of the Abducens Nerve.

(59) The roots of the abducens nerve run nearly directly backward, from the junction of the anterior pyramid with the lower border of the pons Varolii, to the *fasciculus teres* on the floor of the fourth ventricle, at the same level as the roots of the facial nerve. Their course through the pons, however, is slightly undulating upwards and downwards, describing three gentle curves, as shown in the accompanying figure A. As they pass through the pyramid (*a*) they form a single compact bundle, which curves slightly upward. At the back of the pyramid, however, this bundle separates into three or four, which

Fig. A.



* SCHRÖDER VAN DER KOLK, Medulla Oblongata, pp. 117, 118.

† *Loc. cit.* p. 117 (note).

‡ The Grey Substance of the Medulla Oblongata and Trapezium, by JOHN DEAN, M.D., Washington, U.S., 1864, p. 59.

curve first slightly downward, then upward, and again downward as they reach the floor of the ventricle (*b*, *c*). In consequence of this peculiar course, we find that in transverse sections of the pons, at this level, the roots of the abducens nerve are always cut into portions of variable length. Moreover, in transverse sections it is found that they are also somewhat tortuous from *side to side*, and that, unlike the roots of the other cerebral nerves, they curve *outward* instead of inward towards the raphè, as may be seen in figs. 51 and 56, V′, Plate XIII., from the adult brain, and fig. 65, Plate XIV., from the brain of a child five years old.

(60) The *lower* bundles of the roots (V′, fig. 51, Plate XIII.), as they approach the *fasciculus teres*, give off some lateral branches or tufts of fibres which curve outward to the column lying immediately below, or in front of, the great nucleus (Q″), and containing branched nerve-cells, with numerous longitudinal and transverse fibres, the latter of which might easily be mistaken for these branches. They then taper into a kind of narrow band, composed of the remaining fibres, which curves backward and outward round the inner side of the great nucleus (Q″), and along the outer margin of the longitudinal portion (T″) of the loop of the facial nerve. Amongst this band are numerous cells of considerable size and of different shapes, but for the most part oval, and elongated with their processes in the direction of the fibres. They appear to form part of the great nucleus (Q″). Some of the fibres curve outward into the middle of this nucleus; others curve outward round its posterior border, where they meet fibres coming in an opposite direction from the facial nerve (*q*″), the two sets together forming a kind of loop, interspersed with nerve-cells and some longitudinal bundles. The remaining fibres run directly backwards, and crossing the facial roots between the nucleus (Q″) and the longitudinal column (T″) of the facial nerve, diverge into the superficial grey layer of the *fasciculus teres*, at *g*‴. Some of them run more or less directly backward towards the surface; some turn outward over the convex surface of the facial nerve, amongst nerve-cells of considerable size lying at the bottom of the grey layer; while the rest turn inward around the posterior border of the longitudinal column (T″).

(61) As it ascends beneath the floor of the fourth ventricle the common nucleus (Q″, fig. 56, Plate XIII.) becomes gradually smaller. Its *outer* portion, or that which is in connexion with the roots of the *facial* nerve (*q*″), consists, as it does lower down, of numerous large multipolar cells and many longitudinal bundles; but in its *inner* portion, or that which is more immediately connected with the roots of the *abducens* nerve (V′), the cells are for the most part smaller, less numerous, and elongated in different directions, or crescentic; while the longitudinal bundles (represented by the dark masses), which are often embraced by the cells, and of which many are exceedingly thick, have increased considerably in number and are enclosed in the meshes of a network formed by the rootlets of the abducens nerve, exactly as represented in fig. 56. These rootlets unite rather abruptly, like the roots of a plant, to form four or five bundles (V′), which lean against each other at the point of junction, and then separate or diverge slightly as they traverse the pons Varolii outward. Many of the fibres, however, that con-

tribute to form these bundles proceed, not from the nucleus (Q″), but, as already shown, in the case of the lower roots (fig. 51) from different parts of the superficial grey layer of the *fasciculus teres* (g'' g'''), and in their way outward cross the decussating fibres of the facial nerve, just where these are about to enter the longitudinal column (T″).

(62) It is evident, then, that both the abducens and the facial nerves arise each from two separate nuclei, as well as from the same nuclei. In longitudinal sections of the pons Varolii, both in Man and animals, I have repeatedly endeavoured to ascertain whether any of the fibres of the abducens nerve turn round and run longitudinally upward, but I have never been able to perceive the slightest indication of such a course. Indeed, as already stated, the roots curve slightly downward on reaching the *fasciculus teres*, although I have never succeeded in tracing them any further in that direction*.

(63) Having ascertained the relations and connexions of the facial and abducens nuclei and of the longitudinal column (T″) in transverse sections, and in oblique-longitudinal sections along the plane in which this column is entered by the facial nerve, I wished, further, to ascertain their relations to parts situated both above and below them in the medulla. For this purpose I first made a succession of longitudinal but horizontal sections from side to side along the surface of the fourth ventricle, beginning at the level of the facial nerve and nuclei (along the horizontal dotted line in fig. 51, Plate XIII.), and carrying the section downward through the hypoglossal nucleus to about the horizontal dotted line in fig. 32, Plate XI. Such a section of the left half of the medulla and of a small portion of the right half is represented in fig. 57, Plate XIV. Here we find that a large number of fibres belonging to the lower end of the longitudinal column (T″), instead of curving *forward* to the *antero*-lateral part of the *pons* (s'', figs. 53, 54, & q''', fig. 55, Plate XIII.), spread laterally and curve *horizontally* outward just below the surface of the ventricle. Some of these fibres pass through the facial nucleus (Q″), but the greater number sweep round its lower end across the base of the grey tubercle (e' e') at its junction with the inner auditory nucleus, *i* (compare fig. 51, Plate XIII.). In this course they are met by another set of horizontal fibres radiating inwards from the *outer* auditory nucleus or column ($c'o$, fig. 57). In fig. 51, Plate XIII. the fibres

* STILLING, who was the first to trace the facial and abducens nerves to the *fasciculus teres*, considers that both these nerves arise from the common nucleus (Q″). He did not, however, trace any of their roots beyond this point. SCHRÖDER VAN DER KOLK denies that they arise from a common nucleus, and in forming this opinion he seems to have been influenced, as on many other occasions, by physiological views, rather than by actual observation. His objections on the ground that the two nerves have very different functions, are of no value in the face of positive observation. It is certainly difficult to understand why the two nerves, which are apparently never associated in action (except perhaps in certain cases of facial expression), should arise from the same nuclei; but even if the abducens could not be traced to the nuclei of the facial, it is equally difficult to understand why its fibres are *so closely interlaced* with those of the facial, while it is separated by the whole length of the pons Varolii from the *third nerve* with which it is so closely associated in action. SCHRÖDER VAN DER KOLK says that all the roots of the abducens terminate in the floor of the fourth ventricle, and that they seem to bend upward "into a nucleus of ganglionic groups placed externally and superiorly to the facial nerve."

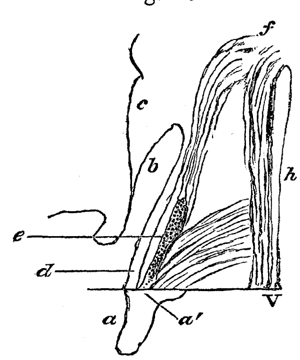
radiating *backward* from *c'o* are well seen, but not so those in question, which run inward from *c'o* along the dotted line. In this figure, however, numerous fibres from *e'i* are seen to sweep through and round the great nucleus (Q″), and in fig. 50 the same are seen at *e* U‴. In fig. 57, Plate XIV. many of the horizontal fibres radiating from the outer auditory nucleus (*c'o* to *e'*) evidently consist of the processes of its large multipolar cells. At the lower end of this nucleus or column (*c' o*) there are numerous longitudinal streaks of grey substance formed from the post-pyramidal and restiform ganglia, as shown in fig. 25, Plate X. The superficial grey layer (*g‴*, fig. 57, Plate XIV.) of the ventricle, at the side of the median furrow (*h″*), as it passes downward becomes reduced to the epithelium of the ventricle on the posterior surface of the raphè; on its outer side some longitudinal fibres descend from the longitudinal portion (T″) of the loop of the facial nerve. This band of fibres inclines somewhat forward as it descends, diminishes in size, and becomes continuous with the surface of the column which runs beneath the front of the hypoglossal nucleus, between the hypoglossal nerve and the raphè (V, fig. 8, Plate VIII. & fig. 32, Plate XI.). At the lower end of fig. 57, Plate XIV., the upper tapering end of the hypoglossal nucleus is represented at J, and beneath its inner side, the longitudinal band of fibres just mentioned is gradually lost to view. On its outer side some plexiform bundles of the white column (J′) ascend to the nucleus (Q″). Still further out is the vagal nucleus (H), and beyond this the lower end of the outer auditory column *c'o* The raphè contains numerous cells of considerable size, and a system of antero-posterior fibres. These are crossed nearly at right angles by another set of *horizontal* decussating fibres, which are continued upward beneath the superficial grey layer that lines the median furrow of the fourth ventricle. The decussating fibres cross the longitudinal band on each side of the raphè somewhat obliquely from above downward and from within outward. Some of them are certainly connected with cells *in* the raphè, and through these they probably communicate with antero-posterior *fibres* of the raphè, and thus establish a complicated commissural connexion between distant parts, or levels, of the medulla. Others are continuous with fibres of the lateral bands, and appear also to proceed from the *raphè*, and not from the opposite side of the medulla. The rest of the decussating fibres cross the raphè and the lateral bands from one side of the medulla to the other. The upper set extend obliquely downwards and outwards to the base (*e'e'*) of the grey tubercle (see also *e'*, fig. 51, Plate XIII.). The lower set traverse the anterior portion of the vagal nucleus (H). Many of these proceed from the cells of the hypoglossal nucleus, as shown in fig. 31, Plate X.

(64) Fig. 58, Plate XIV. represents a similar horizontal-longitudinal section a little deeper from the surface of the fourth ventricle. Figs. 59 & 60, Plate XIV. are *transverse* sections of the left lateral half of the medulla at the upper and lower ends of this longitudinal section. In figs. 58 & 59 the upper lines of section correspond. F is the raphè immediately below the median furrow of the ventricle. V is the white column between the raphè and the entrance of the abducens nerve (V′) into the nucleus (Q″). *e'* is the base of the grey tubercle. *c' o* the *outer* auditory nucleus. The *lower* line of fig. 58

corresponds to the *upper* line of the transverse section, fig. 60, in which J is the anterior portion of the hypoglossal nucleus. V is the white column between it and the raphè. O″ is the white olivary column lying between it and the vagal nucleus (H). The slender longitudinal column of the vagus is seen at *n*; and *c′ o′* is the lower end of the outer auditory nucleus, formed by the grey substance of the restiform body and posterior pyramid. It will be seen, then, that in fig. 59, the white column (V) between the raphè (F) and the entrance of the abducens nerve into the nucleus (Q″) is continuous, in fig. 60, with the white column (V) between the *hypoglossal* nucleus (J) and the raphè. This column (V) is seen longitudinally in fig. 58, and is only a deeper longitudinal section of the lateral band which descends in fig. 57, from the longitudinal portion of the loop (T″) of the facial nerve. At the lower end of fig. 58, this white column is seen on the *inner* side of the remains of the hypoglossal nucleus (J), instead of immediately beneath it. The olivary bundles (*o″*, fig. 58) run up in a plexiform manner, partly from the remains of the hypoglossal nucleus (J), through the facial nucleus (Q″).

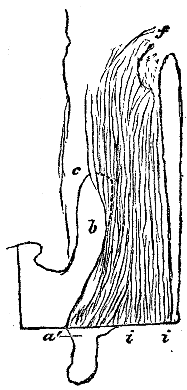
(65) From the longitudinal portion of the loop of the facial nerve, some fibres *ascend* along the side of the median furrow, in company with those which ascend from its *under* surface. They all curve upward and forward beneath the *inner* portion of the superficial grey layer of the ventricle to form part of the longitudinal column immediately beneath the nucleus of the third nerve on the same side. Adjoining them on the outer side, the longitudinal bundles which passed through and beneath the common nucleus (Q″) of the facial and abducens nerves, now ascend beneath the *outer* portion of the superficial grey layer, and contribute to form part of the crescentic column immediately beneath the same side of the third nerve. A longitudinal but horizontal section, from below upward, along the floor of the fourth ventricle, on the left side, and at the inner surface of the superficial grey layer, is represented in fig. B. *a* is the grey tubercle of ROLANDO, seen in the transversely-cut end of the pons Varolii, just above the level of the facial nerve. From its base at *a′* the longitudinal section is carried upward along the fourth ventricle. *b* is the cut surface of the superior peduncle of the cerebellum passing beneath the fillet *c*. The outer border of the grey tubercle running upward and inward, from its base, along the inner side of the superior peduncle is seen at *d*. Along the inner side of this is a layer of black matter or pigmentary cells (*e*), from which a number of fibres ascend and curve inward to the side of the nucleus (*f*) of the third nerve. From the inner side of the grey tubercle (*a′*)—at its junction with the upward continuation of the inner auditory nucleus—and from the pigmentary matter, transverse fibres ascend obliquely to the superficial grey layer (*h*) at the side of the median furrow of the ventricle. On the outer side of this furrow, the band of white fibres (V) ascends from the loop of the facial nerve, and from beneath it, to the side of the nucleus (*f*) of the third nerve.

Fig. B.



(66) Fig. C represents the next deeper, but similar kind of, section. The pigmentary matter at the inner side of the grey tubercle, as well as the oblique fibres, have disappeared; but other fibres issuing from the base of the grey tubercle (d') ascend and curve inward to the nucleus of the third nerve (f). Adjoining these on their inner side, and ascending to the same place, are the white fibres ($i\,i$), which have passed through and beneath the common nucleus of the facial and abducens nerves, as well as those fibres which run along the side of the median furrow. Hence it appears *that both the base of the grey tubercle into which the sensory root of the trigeminus penetrates, and the bundles of fibres which pass through and beneath the common nucleus* (Q''), *are connected with the nucleus of the third nerve.*

Fig. C.



Of the Trapezium and Superior Olivary Bodies.

(67) In the Proceedings of the Royal Society for June 1857, I first showed that the transverse band of fibres known in animals as the trapezium encloses on each side a remarkable grey nucleus which bears a striking resemblance to the olivary body; and I further showed, at the same time, that the trapezium with its nucleus exists also in Man, but that it is covered and concealed by transverse fibres at the lower border of the pons. About a year later the grey nuclei of the trapezium, *in animals*, were described by SCHRÖDER VAN DER KOLK, and called by him the superior olivary bodies*. As the structure of these nuclei has since been more fully investigated by DEAN†, it will be unnecessary to go over the same ground; and therefore I shall only point out the chief differences in structure and position between the trapezium of Man and that of animals generally.

(68) On turning to fig. 48, Plate XII., which represents a transverse section of the left lateral half of the medulla of the Rabbit on a level with the auditory nerve, a remarkable group or column of large cells (s) will be found imbedded in the anterior part of the antero-lateral column, on the outer side of the anterior pyramid. This group of cells was first pointed out by myself‡, and was subsequently named by DEAN the *antero-lateral nucleus.* It begins low down in the medulla, both in Man and animals, and ascends as high as the trapezium §. Here, however, we find it replaced, exactly in the same spot, by another nucleus of a different form and somewhat different structure. This consists of a convoluted grey lamina like that of the olivary body, but the convolutions are few. In the Rabbit (s'', fig. 61, Plate XIV.) and in the Cat, in which it is largely developed, it assumes rather a sigmoid form, with some small masses on its inner side. In the Sheep and other Ruminantia there is less trace of convolutions. The cells of the lamina are smaller than those of the *antero-lateral* nucleus, and the course of its

* SCHRÖDER VAN DER KOLK, Medulla Oblongata, 1858.

† Medulla Oblongata and Trapezium. By JOHN DEAN, M.D.

‡ Philosophical Transactions, 1858. § Ibid.

fibres very much resembles that of the inferior olivary body. Notwithstanding, however, the resemblance of this nucleus, in form and structure, to the olivary body, its *position* is different, being situated *behind the trapezium*; while the lower olivary body in Mammalia is behind the anterior pyramid*. The trapezium consists, for the most part, of transverse bundles, which are partially separated from each other by flat longitudinal bundles of the antero-lateral column. These transverse bundles ($p'p''$, fig. 61, Plate XIV.) proceed, as arciform fibres, from the restiform body on each side, and from the remains of the outer auditory nucleus. They sweep round the front of the grey tubercle (e), then cross the facial nerve (q''), and run inward, in front of the upper olivary body (s''), to the back of the anterior pyramid (y), where they decussate across the raphè with their fellows of the opposite side. DEAN states that many separate bundles turn off and curve quite around the nucleus, "either penetrating its interior or completely surrounding it, till the upper side is reached, where the bundle frequently turns still more and enters the central portion of the mass, radiating in the same manner as the bundles which enter the convolutions in the lamina of the human olivaries"†.

(69) The prominence of the trapezium at the surface of the medulla is proportionate to the development of the nucleus within. In the Cat it projects on each side of the anterior pyramid as a large convex and somewhat oval mass‡. In the Dog, the Sheep and other Ruminants, it is less prominent, and appears as a flattened band in the same situation. It is present in all the Quadrumana, but although it varies in size in different species, it is generally small, and, in strong contrast to that of the Cat, is sunk deeply in the fossa at the outer side of the pyramid. Fig. 62, Plate XIV. represents a transverse section of the left lateral half of the medulla of the Orang Outang, on a level with the facial nerves. When compared with that of the Rabbit (fig. 61, Plate XIV.) we find that the anterior pyramid (y) is enormously developed, and that the trapezium (p'') is sunk between it and the facial nerve (q''). Behind the transverse fibres of the trapezium the lamina of the superior olivary body (s'') appears in the form of a simple loop or fold, overlaid, on its outer side, by the group of large multipolar cells constituting the nucleus (U) of the motor root of the trigeminus. On each side of the raphè the decussating fibres of the trapezium are thickly interspersed with small cells in irregular groups, one of which extends forward in a tapering form along the inner side of the pyramid. The surface also of the pyramid is covered with a thick layer of small cells (y'), which extends backward along the inner edge of the raphè, as far as the level of the decussating fibres of the trapezium. Nothing of the kind is found in the Rabbit, or in any of the Mammalia.

(70) Fig. 63, Plate XIV. represents a transverse section of the left side of the human pons Varolii, at the same level, and magnified to the same extent as figs. 61 & 62. After examining the trapezium, first in the Rabbit and then in the Orang Outang, it will not be difficult to recognize the same structure in Man. As usual, it lies partly

* "Medulla Oblongata," Philosophical Transactions, 1858. † DEAN, Medulla Oblongata, p. 64.

‡ See my "Medulla Oblongata," Philosophical Transactions, 1858, fig. 4, Plate XII.

behind and partly on the outer side of the anterior pyramid (y), where in animals it forms the surface of the medulla (p'', figs. 61 & 62); while in Man (fig. 63) it is covered and concealed at this point by the transverse bundles of the lower portion of the *pons* enclosing a quantity of grey substance, which consists of irregular masses of small cells ($y'' y''$). This grey substance extends round the front of the anterior pyramid (y) to its inner side, where it forms a deep and broad layer (y''') next the raphè. The transverse bundles of the trapezium are numerous and strongly marked. Along the central line of the *pons* they decussate as usual with their fellows of the opposite side, the most anterior being imbedded in a mass of grey substance (y'''), which is denser, and contains larger cells than that which is continuous around the front of the pyramid to y''. On the outer side the fibres of the trapezium run into and round the front of the superior olivary body (s''), crossing the abducens nerve (V$'$); and as they reach the inner side of the facial nerve (q''), they intersect each other in a complicated manner amongst irregular masses of grey substance consisting of granules and small nuclei. They then cross the facial nerve and sweep round the extremity of the grey tubercle (e) to the middle peduncle of the cerebellum. These bundles appear to consist of several sets of commissural fibres: 1, between the superior olivary body, the grey substance at the back of the pyramid, and the cerebellum; 2, between the two opposite olivary bodies.

(71) In Man the superior olivary body is not nearly so distinctly convoluted as in the Cat or the Rabbit, nor is it nearly so large in proportion to the size of the brain. It has the appearance, rather, of two or three ill-defined masses in continuity with each other. The majority of its cells are somewhat smaller than those of the inferior olivary body. There is one remarkable point in which this portion of the medulla, both of Man and the Orang Outang, differs from that of Mammalia. In figs. 62 & 63, the superior olivary is overlaid by the group of large multipolar cells (U) constituting the nucleus of the motor root of the trigeminus, and connected by numerous fibres with the common nucleus (Q$''$) of the facial and abducens nerves. In Mammalia this nucleus of the trigeminus is not found in the same situation.

(72) Schröder van der Kolk does not appear to have detected the existence of the trapezium in the human pons Varolii. Stilling described and figured this part in the *human pons* *, but he was not aware that it is homologous with the trapezium of animals; and as he was not acquainted with the nucleus or superior olivary body enclosed by the fibres of the trapezium, he called this nucleus, in Man, "quasi appendix nuclei inferioris nervi trigemini, ad formam scafi."

* Stilling, Pons Varolii, tab. ii. *s s*.

CHAPTER III.

(73) Although in the course of these researches I have carefully endeavoured to investigate the facts independently of any particular physiological views with which they might seem to be connected, I shall nevertheless conclude this memoir with a few remarks on some of the physiological and pathological points which they either modify or explain.

(74) Before the publication of my memoir "On the Medulla Oblongata," in 1858, it was believed by anatomists that the decussating fibres of the anterior pyramids are continuous only with the lateral columns of the opposite side of the spinal cord. I have shown, however, that they are connected not only with the *lateral*, but with the *anterior* columns, and with both the anterior and posterior *grey substance.* These facts, which must modify to a certain extent the current opinion concerning the functions of the anterior pyramids, have been confirmed by the investigations of M. VULPIAN, announced in his recent and valuable work on the 'Physiology of the Nervous System*. "Nos recherches anatomiques, d'accord en grande partie avec celles de M. LOCKHART CLARKE, montrent que les pyramides antérieures sont formées par des fibres émanées: (1) des faisceaux antérieurs; (2) des faisceaux latéraux; (3) des faisceaux postérieurs; (4) de la substance grise de la moëlle épinière. A ces fibres, il faut même en ajouter d'autres qui font partie du groupe des fibres arciformes, et qui constituent parfois, soit d'un seul côté, soit, mais plus rarement, des deux côtés du bulbe, une portion assez notable de la pyramide antérieure†."

(75) Besides the antero-lateral white columns, the particular parts with which I have shown the decussating fibres of the anterior pyramids to be connected, are (1) the antero-lateral *grey* substance, (2) the anterior border of the caput cornu, or expanded extremity of the posterior horn, (3) the base of the cervix cornu on each side of the central canal, (4) the continuation of this part of the cervix cornu in the posterior column, forming its grey nucleus, and subsequently contributing to form a large portion of the outer nucleus of the auditory nerve, and (5) the side of the spinal-accessory and hypoglossal nuclei. From some of these facts M. VULPIAN thinks it not improbable that the anterior pyramids are to a certain degree sensitive and excito-motor: "Nous présumons," he remarks, "que les pyramides antérieures pourraient bien être sensitives et excito-motrices, parceque l'anatomie nous démontre qu'elles sont en relation avec les faisceaux postérieurs et avec les diverses parties de la substance grise"‡. Their connexions, however, with the sensory portions of the medulla oblongata and cord do not afford sufficient ground for the conclusion that they are sensitive; although it is presumable that, by virtue of these connexions, they are excito-motor, probably through the grey substance within the pyramids themselves, the pons Varolii, or both.

* Leçons sur la Physiologie Générale et Comparée du Système Nerveux. Par A. VULPIAN, Paris, 1866.

† Ibid. p. 468. ‡ Ibid. p. 484.

(76) Now some of the connexions which I have pointed out between the fibres of the anterior pyramids and certain other parts of the medulla oblongata, are exceedingly interesting in a physiological point of view*. I have shown, both now and on former occasions, that the spinal-accessory nerve may be traced to several different centres of origin. Its upper rootlets arise from a special nucleus or column of cells, which descends behind the canal to about the level of the lower end of the olivary body; while its lower rootlets arise from the *lateral grey substance*, and from the *anterior grey* substance which gives origin to the *lower* roots of the *hypoglossal* nerve and to the anterior roots of the *spinal* nerves in the cervical region. According to BENDZ and CLAUDE BERNARD, the *upper* roots—which I have shown to arise from the special nucleus behind the central canal—go to form the *internal* branch which joins the vagus and is distributed through it to the larynx, pharynx, and palate; while the *lower* rootlets—which we have seen to arise from the antero-lateral grey substance of the cord and of the lower part of the medulla—are collected into the *external* branch, which supplies the trapezius and sternomastoid muscles employed in voluntary and forced efforts of respiration. Now it is particularly interesting to find, as I first showed in 1858, that decussating fibres of the anterior pyramid in their course downward from the cerebrum, turn obliquely backward to the point about which the *special nucleus* and *upper roots cease to arise*, and the *lower roots begin*. In fig. 5, Plate VIII., we see these bundles crossing each other from the opposite anterior pyramids (*y y*), then curving backward round the sides of the hypoglossal nuclei (t'), and of the special spinal-accessory nuclei (*t*). Their outer bundles are connected at *n*, fig. 5, with the lateral grey substance where the *lower* roots of the spinal-accessory nerve *r* begin (fig. 28, Plate X.). In fig. 27, Plate X. we have an oblique transverse section of the left side of the medulla in the direction L, *t*, fig. 5, Plate VIII. In this section we see the transversely-cut ends of these decussating bundles (n'') of the anterior pyramids, with fibres extending amongst them from the spinal-accessory nucleus (*t t*). On their outer side we see the slender longitudinal column (n') ascending, from the point where the higher roots cease and the lower roots begin, to the side of the vagal nucleus, as already described (§ 15). Moreover, in descending the medulla oblongata and cervical region of the spinal cord, the decussating fibres of the anterior pyramids pass into and through the antero-lateral grey substance where the lowest roots continue to arise (see figs. 4, 3, 2, Plate VIII.). There appears, then, to be scarcely a doubt that *these* particular decussating bundles of the anterior pyramids are the channels through which the will influences the movements of respiration. It is very probable also that they are functionally related, in the same way, to the hypoglossal nuclei (t'), or at least, that they are *one* of the channels through which the will acts on the hypoglossal nerves.

(77) The functions of the olivary bodies have been the subject of much discussion amongst physiologists of different ages. WILLIS, I believe, was the first who considered them as the central organs of articulate speech†. BURDACH and RETZIUS regarded them

* The reperusal of the five last paragraphs of section 15 is here recommended.

† Cerebri Anatome.

as subservient to both speech and expression. DUGÈS and SOLLY have adopted the opinion of WILLIS. SERRES concluded, from pathological facts, that the olivary bodies influence the movements of the heart. According to him, isolated and chronic alterations of these bodies cause a jerking and irregular action of the heart*. He also found that stammering was associated with structural alterations of the upper parts of the olivary bodies close to the pons. In my memoir "On the Medulla Oblongata" (1858), I concluded, on anatomical grounds, that these bodies are probably the coordinating centres for the different nuclei of the medulla oblongata; that is, that they are the motor and associating agents by which the different complex movements dependent on the medulla are carried on. SCHRÖDER VAN DER KOLK concluded, both from anatomy and pathology, that the olivary bodies are subservient chiefly to articulate speech and deglutition. He collected from different sources, and recorded, several cases of loss of speech, in which these bodies were more or less altered in structure. Two exceedingly interesting cases of the same kind have come under my own observation.

(78) A lady, ætat 55, fell down suddenly in a state of unconsciousness. When she recovered her senses, she was hemiplegic on the right side, and unable to speak. This was the state in which I found her. She regained the use of her arm and leg, with only some slight remaining weakness, and the power of articulation returned with only some slight impediment. During the next four or five years she had several slight and partial attacks of paralysis, with some additional defect of articulation. She had chalky concretions in the joints of her fingers, and during some of the paralytic attacks, she had what appeared to be gouty inflammation of their joints. On subsiding it left behind chalky deposits. Two years before her death deglutition became much impaired. A year later she had an attack of partial unconsciousness, which rapidly passed away; but from that time the power of articulation was almost lost. She could say "Yes," "No," "Shan't," and one or two other short words, but nothing more. At this time she was almost wholly unable to protrude her tongue. During two months or more she entirely lost the power to swallow, and was nourished by means of injections. She took strychnine and iron; and regained the power of deglutition sufficiently to dispense with injections, although she was a long time in swallowing even a small quantity of liquid food. She swallowed best in a recumbent posture, and it was evident that the pharyngeal muscles were considerably paralysed. A large collection of mucus in the air-passages frequently excited spasmodic coughing; but she had scarcely any voluntary power over the respiratory muscles, and was unable to cough voluntarily. She could scarcely do more than *whisper* the few words she was able to articulate. The power of straining was completely lost, and large quantities of fæcal matter collected in the rectum. Both arms and legs were very weak, especially the latter, so that she could scarcely walk, even with assistance. Sensation was unaffected.

On post-mortem examination the kidneys were found to be very small and very granular on their surface; their cortical portions were much atrophied, with two or three

* Anatomie Comparée du Cerveau, tom. ii. p. 231.

cysts on their surface. The heart was exceedingly flabby, soft, and yellowish, with accumulation of fat outside the left ventricle, which was dilated, and broke down easily under the fingers. There was no disease of mitral valve. The wall of the right ventricle was exceedingly thin—nearly as thin as that of a healthy auricle. The tricuspid valve was healthy.

At the base of the brain the arteries were atheromatous. The membranes at its upper surface were thick and opaque, with some sub-arachnoid fluid and numerous patches of white, flaky, and granular matter. They were adherent to the calvarium which was unusually thick. About four ounces of fluid flowed into the calvarium on removing the brain. The surface of the anterior lobes of the cerebrum was much depressed and atrophied. The grey substance of convolutions was about the usual colour. The under surface of the right crus cerebri was softened. On the outer part of the right corpus striatum were the remains of an old clot, about the size of a horse-bean. The substance beneath it was much softened. In the middle of the right optic thalamus were the remains of another and much larger clot. On the surface of the *left* optic thalamus was a softened and chocolate-coloured depression, and beneath this were the remains of a small clot.

Cerebellum.—In the central white substance, on each side, was a cyst containing turbid fluid. That on the right was about as large as a moderate-sized hazel-nut, and destroyed only part of the convoluted lamina of the corpus dentatum; that on the left was somewhat larger, and destroyed nearly the whole of the lamina. The fluid in the cysts consisted of globular aggregations of oil-globules, some of which were tinted with brown and yellow, and accompanied with crystals and granules of hæmatoidin.

The medulla oblongata was curiously misshapen, and tilted to the right side. This displacement appeared to be due chiefly to atrophy of the right corpus olivare. At the lower two-thirds of the olive the atrophy was considerable, but diminished along the upper third. Fig. 64, Plate XIV. is an exact representation of a transverse section of the medulla through the middle of the olivary bodies. Not only was the right olivary body exceedingly reduced in bulk, but the greater number of its nerve-cells were wasted to granular points or small granular masses tinted brown or yellow by pigment, as the accompanying preparations very distinctly show*. Between the olivary bodies the central part of the medulla was softened, so that its lateral halves readily separated along the median raphè. Neither the hypoglossal nor the vagal nuclei were reduced in bulk to any remarkable degree; but the vagal nucleus, which in Man normally contains a certain number of dark pigmentary cells, contained these in much greater number than usual; and many of the cells of the hypoglossal nucleus had lost some of their sharpness of outline, and contained more than their natural amount of pigment.

* A case of extreme atrophy of the nerve-cells of the spinal cord, in muscular atrophy, has been published by me in the British and Foreign Medico-Chirurgical Review, July 1862, and two others in the Medico-Chirurgical Transactions, 1867 and 1868, with drawings. In No. XIII. of BEALE's 'Archives of Medicine,' I recorded another case, in which I described the successive changes by which the cells undergo the process of degeneration.

All the central parts of the pons Varolii were very much softened. The softening involved a large portion of the prolongations of the anterior pyramids, and extended backward to within a sixth of an inch of the fourth ventricle.

(79) The second case was a gentleman, who, having recovered, in a great degree, from an attack of *left* hemiplegia, with some difficulty of articulation, suddenly found that he had altogether lost the power of speech, and then became insensible for a few hours. He had total paralysis of the tongue on both sides. He was unable to cough, and had very great difficulty in swallowing. Sensation was unimpaired. On laryngoscopic examination by Dr. MORELL MACKENZIE, there did not appear to be any paralysis of the vocal cords. The patient was under the care of Dr. HUGHLINGS JACKSON, with whom I saw him, from time to time, to the period of his death. The post-mortem examination was made by Dr. HUGHLINGS JACKSON, who sent me the brain, medulla oblongata, and spinal cord.

I found many of the principal arteries of the brain, particularly the basilar, the posterior, middle, and anterior cerebral, and the right carotid loaded, and in some places nearly choked up, with atheromatous deposit. I shall not give a detailed description of the numerous lesions which, as might be expected from such a condition of the arteries, I found in different parts of the brain, but shall only state that the convolutions of the middle and anterior lobes, especially those along the front of the middle lobes, bordering the fissure of SYLVIUS, and those of the *insula*, were much softer and paler than natural. The anterior perforated space, and the orbital and adjacent convolutions, were particularly soft. Both thalami optici were soft. On the surface of the *left* corpus striatum was a dark brown and softened depression about the size of a pea. Over the posterior half of the *right* corpus striatum and outer and fore part of the thalamus opticus, there was a chocolate-coloured and softened mass about the size of a hazel-nut. Beneath this the substance of both these bodies was very soft, and about a third of an inch from their surface were the remains of an old clot.

Many parts of the cerebellum were exceedingly soft. The corpus dentatum on the *left* side was almost wholly destroyed by a round cyst containing turbid fluid.

The surface of the fourth ventricle was softer than natural, and of a pale-yellow or cream-colour. In the medulla oblongata, on the left side, a small rust-coloured spot was observed at the origin of the vagus nerve; and in the same section there was a dark rust-coloured streak on the inner side of the right anterior pyramid. A third of an inch below the pons Varolii another rust-coloured spot, about the size of an ordinary pin's head, was found in the substance of the posterior convolutions of the olivary body. This was proved by microscopic examination to be the remains of an old clot. It descended the medulla about the third of an inch, gradually diminishing and at length occupying the part immediately behind the convolutions of the olivary lamina, amongst the deep arciform fibres.

(80) Valuable as these cases are in many respects, they by no means prove that the loss of articulate speech was due to the lesions in the olivary bodies; since it is impos-

sible to say how far it might have been dependent on the numerous and extensive alterations which were found in other parts of the brain, particularly about the nuclei of the vagal and hypoglossal nuclei. The same objection may be made to SCHRÖDER VAN DER KOLK'S cases, when they are adduced as proofs that the olivary bodies are the central organs of articulate speech.

(81) Neither are the anatomical points which SCHRÖDER VAN DER KOLK brings forward in support of this opinion exactly as he states them to be. According to his theory, the olivary bodies effect the *bilateral* movement of the tongue by their action on the hypoglossal nuclei, because the actions of these nuclei are *unilateral*; "for the greater part of each nucleus," he says "seems to be isolated in its action, and not to be connected with that of the other side." Now it is not true that the hypoglossal nuclei are scarcely connected with each other other; for, as may be seen, especially in longitudinal and horizontal sections along the fourth ventricle, at different depths of the nuclei, there is a very evident decussation of fine fibres; and at the upper end of the nucleus, the commissural fibres between the anterior groups of cells are particularly striking, as may be seen at J, fig. 57, Plate XIV. VULPIAN speaks almost in derision of SCHRÖDER VAN DER KOLK'S theory of the action of the olivary bundles; but, nevertheless, there are not wanting anatomical facts in favour of the opinion that these bodies are subservient to articulate speech. In this process, the tongue, the lips, the jaws and the expiratory muscles are simultaneously combined in action. Now I have already shown that the connexion of the olivary bodies with the hypoglossal nuclei is very striking. I have also shown that a column of cells connected with longitudinal fibres and continuous with the fasciculus teres, whence the facial nerve takes its origin, descends low down into the medulla and lies at the back of the hypoglossal nucleus (see K', fig. 25, Plate X., and figs. 38, 39 & 40, Plate XI.). Moreover, a band of fibres descending from the loop of the facial nerve (T'', fig. 57, Plate XIV.) passes downwards beneath the hypoglossal nucleus (J). The close commissural connexion between the hypoglossal nucleus (J', fig. 31, Plate X.) and the vagal nucleus (H, H') has been already pointed out. And lastly, we have seen that the lower end of the column of cells constituting the nucleus of the motor root of the trigeminus is imbedded in the columns which ascend from the olivary body. But whether the olivary bodies really act through the channels just mentioned, and thus coordinate the movements of articulation, is not proved by the anatomical facts alone. On the other hand, amongst birds, in which scarcely any traces of olivary bodies are to be found, the Parrot-tribe have the power of distinctly articulating particular words; while in the Porpoise, which emits only a kind of moaning sound, the olivary bodies are enormously developed*. Experiment throws no light whatever on this subject, so

* I obtained, through the kindness of Mr. W. H. FLOWER, of the College of Surgeons, part of the medulla of a Porpoise, and found that the large olivary bodies overlaying the pyramids were everywhere crowded with nerve-cells. The cerebrum of the Porpoise is large and globular, and the convolutions are very numerous and deep. The only remarkable points in the actions of the animal, are its great agility and vivacity of movement, and its extraordinary speed and muscular power.

that our only hope is in some fortunate cases of disease, in which the power of speech is perfect, while the olivary bodies are considerably altered in structure; or in which the olivary bodies, *only*, are damaged, while the power of speech is lost. Either of such cases, determined with accuracy, would set the question at rest. M. VULPIAN has recently recorded a case which seems to be opposed to the opinion that the olivary bodies are concerned in speech, since these bodies were altered in structure while speech remained perfect to the last. The examination, however, does not appear to have been sufficiently precise to justify a positive conclusion. I give his own words: "Les olives du bulbe, surtout la gauche, offraient une sclérose bien manifeste, quoique peu profonde, de leur tiers moyen, et cependant,—ce qui n'est pas sans importance, au point de vue d'une des hypothèses relatives aux fonctions de ces parties,—la parole est restée parfaitement nette jusqu'à la fin de la vie" *.

(82) Deglutition is another process to which the olivary bodies have been regarded as subservient. If they have any share in this process, it is probably only in the first or voluntary stage, in which the food is pressed through the anterior palatine arch by the cooperation of the buccinator, the mylohyoid, the intrinsic muscles of the tongue, and the styloglossi. The second stage, which is purely reflex and involuntary, is probably effected solely through the intimate and important connexions which I have pointed out between the nuclei of the trigeminus, the hypoglossus, the glossopharyngeal, the spinal-accessory, the vagus, and the facial. The third stage is reflex simply through the vagus and spinal-accessory. Cases are on record in which the tongue, while entirely removed from all voluntory influence, co-operates, nevertheless, perfectly with the muscles of the fauces and pharynx in the second reflex stage of deglutition. The demonstration which I have given in this memoir, of the close anatomical connexion, in different ways, between the nuclei of the hypoglossal, vagus, spinal-accessory, facial and trigeminal nerves throws an important light on the manner in which the complex and associate muscular actions concerned in deglutition, vocalization, and articulation may be effected; and explains, in an interesting way, certain forms of partial or complete paralysis to which the muscles employed in these acts are subject. Dr. HUGHLINGS JACKSON was kind enough to show me one of his patients in whom there was complete paralysis and wasting of the right side of the tongue †, with paralysis of the same side of the palate and vocal cords, as shown by the laryngoscope. The man had great difficulty of swallowing, and soreness of throat. He was unable to cough, or rather he could not shut the larynx in coughing. He was weak on both sides, but especially on the right. The right shoulder was much lower than the left, and he was unable to shrug it up as he could the other. He could not *whistle* so well as formerly; but he could *articulate in a whisper very well.* Here we have paralysis of the spinal-accessory nerve on one side, supplying the vocal cords and palate; total paralysis of one hypoglossal nerve, and

* VULPIAN, Leçons sur la Physiologie, p. 495 (note).

† The muscles of the tongue, when paralyzed, suffer atrophy much more rapidly than other muscles under the same conditions.

apparently partial paralysis of the facial supplying the orbicularis oris. I have already shown that some of the roots, both of the spinal-accessory and vagus nerves, may be traced directly into the hypoglossal nucleus, and that, on the other hand, numerous nerve-cells of the hypoglossal nucleus, as may be seen in fig. 31, Plate X., send their processes deeply into the vagal nucleus. Moreover, we have seen in fig. 25, Plate X., just below the olivary body, that a small column of cells (K′) mixed with numerous longitudinal fibres, ascends, and increases as it ascends to the facial nucleus. It is first situated between the spinal-accessory and hypoglossal nuclei, then between the latter nucleus and the vagus (H, fig. 38, Plate XI.), and higher up (fig. 39), where the hypoglossal nucleus ceases, it lies at the inner side of the glossopharyngeal (*t*) and inner auditory nucleus (*i*), with both of which it is connected, as well as with the motor nucleus of the trigeminus (U). Now it is not at all improbable that this column of cells (K′) at fig. 26, Plate X., and a little higher up, is the channel of communication for that portion of the facial nerve which supplies the muscles about the lips and mouth. We know that this portion of the facial is frequently paralyzed alone, and must therefore be, to a certain extent, independent of the rest of the nerve; and we also know how closely and frequently it is associated alone in function with the spinal-accessory and hypoglossal nerve in the operations of articulation and vocalization. By now referring to fig. 25, Plate X. (which of course is considerably magnified*), it will be understood that in this section and in others a little higher up, a small spot of lesion—either a clot or a disintegration in the spinal-accessory nucleus (H)—would more or less paralyze the voice. A similar lesion in the hypoglossal nucleus (J) would paralyze one side of the tongue. One which destroyed K′, would cut off the mouth and lips from co-operation with the voice and tongue; and a lesion that injured, more or less, all three of these nuclei, which are in such close apposition, would paralyze, more or less, at the same time, the voice, tongue, and lips. But of course when I state that the small column (K′) is subservient to the movements of the muscles about the mouth in the co-ordinate movements of articulation, the statement is wholly conjectural, although probably true.

(83) Now there is a form of disease which was first distinguished from ordinary facial paralysis, by DUCHENNE (de Boulogne), and which has been called by TROUSSEAU "Paralysie Glosso-labio-pharyngée." It consists of paralysis of the orbicular muscle of the lips, of the tongue, of the velum palati, and of some of the muscles of the larynx. The patient *gradually* loses all power of articulation; he is unable to protrude the tongue; deglutition becomes difficult; the velum palati is insensible to the influence of different kinds of stimulants; the posterior nares can no longer be closed by the velum and muscles of the posterior palatine arch, so that the voice becomes nasal; the mucous membrane of the larynx frequently becomes insensible to irritation, and fits of suffocation ensue. It is evident, therefore, that in this curious disease, the hypoglossal, the spinal-accessory, part of the vagus, and part of the facial, are together more or less injured.

* I may here state that this figure is an almost *photographically exact* representation of all the parts of the preparation from which it was drawn.

The disease is not common, and little is known of its morbid anatomy. In one case only, TROUSSEAU examined with the greatest care, the brain, the cord, and the roots of the nerves, but found nothing unusual; nevertheless, something certainly was to be found, and lesions, sufficient to produce the symptoms, might very easily exist in the nuclei at the floor of the fourth ventricle without detection, or in the roots of the nerves arising from them. It is probable, however, that in none of these cases the lesion is limited to the medulla. There is sometimes weakness of one side of the body or of one arm; and sometimes, towards the end, the limbs become flexed on each other, and the patient is drawn up in a heap*.

(84) Whether or not the olivary bodies be subservient to the operations of speech and deglutition, it is quite certain that these are not their only functions. We have seen that in all the Mammalia, except the mute Porpoise, they are very much smaller than in the Monkey, which is wholly unable to articulate, and in which the act of deglutition has nothing peculiar. But even if it should be imagined by some that the "chattering" of the Monkey is a kind of speech, the Orang Outang and Chimpanzee are not more gifted in this respect than the inferior tribes, and yet their olivary bodies are much more highly developed, as I have already shown. Now, except their superior intelligence, the only endowments that distinguish the Ape-tribe from all other Mammalia, are their singular faculty of imitation and gesticulation, and their power of expressing a variety of emotions, of which they are very susceptible; and in these respects the Orang Outang is by far the most highly endowed. LE COMTE, in his 'History of China,' says of one of these animals which he saw in the Straits of Molucca, that its actions so strongly resembled those of Man, and its passions were so expressive and lively, that a dumb person could scarcely make himself better understood. It signified its joy and anger by stamping with its foot on the ground; it could dance, and would sometimes cry like a child. These animals are also distinguished for their surprising agility and muscular power. Now since the olivary bodies are larger in the Ape-tribe than in any other animals, and largest of all in the Orang Outang, which is the most highly endowed with the power of expressing its emotions and desires, it appears to be extremely probable that this power is dependent on the co-ordinating functions of the olivary bodies. Nor are these functions limited to the medulla oblongata and the parts supplied by its nerves. They extend to the spinal cord, and to the sympathetic influencing the glandular secretions and the diameter of the capillary vessels, through the vaso-motor nerves.

(85) Anatomists and physiologists are too much in the habit of regarding the olivary bodies as if they were connected only with the medulla oblongata and some other parts

* Since the above was written Ihave read TROUSSEAU's account of the post-mortem examination of a case in which the roots of the vagus were atrophied; the roots of the right hypoglossal were also atrophied to mere filaments; the roots of the spinal-accessory were on both sides small, and of a greyish colour. In the neurilemma there was a fatty granular substance. The anterior spinal roots were atrophied, especially near the roots of the spinal-accessory. Many other anterior spinal roots were diminished in size. The grey substance of the cord was of deeper colour and harder than natural. I shall be very glad to examine the brain, medulla, and cord of patients who may die of this disease.

of the brain. On this and on other occasions I have pointed out the way in which the different parts of the grey and white substances of the spinal cord are disposed or modified in the medulla oblongata. I have shown (1°) that from the outer (posterior) part of the cervix or neck of the posterior horn are developed the post-pyramidal and restiform nuclei which, higher up, form the nuclei of the auditory nerve, while the caput cornu, or dilated extremity of the posterior horn, is thrown aside to be traversed by the vagus and glossopharyngeal nerves, and ultimately to become the principal nucleus of the large root of the trigeminus; (2°) that from the *base* of the cervix cornu, *behind* the central canal, is developed the *special* nucleus for the spinal-accessory, vagus and glossopharyngeal nerves; (3°) that the *base* of the *anterior* grey substance *in front* and at the side of the central canal is developed into, or at least replaced by, the *special* nucleus giving origin to the *upper* roots of the hypoglossal nerve; (4°) that the *lateral* parts of the grey substance between the extremitities of the anterior and posterior horns, including what I have named the *tractus intermedio-lateralis*, is especially connected with the *lower* roots of the spinal-accessory nerve; and (5°) that, in ascending from the cord to the medulla, the remaining part of the anterior grey substance, which lies against the inner side of the anterior column, or the so-called non-decussating portion of the pyramid, and from which the *lowest* set of hypoglossal roots arise,—gives place to the groups of cells forming the lower end of the olivary body, which, as it swells out, becomes connected with the anterior part of the antero-lateral column (see figs. 6, 7 & 8, Plate VIII.). We have only to make a longitudinal section obliquely inward and backward through this column and the olivary body to see the connexion between them*. We must therefore regard the olivary body as a large motor nucleus, which is directly continuous by its white and grey substances, with the *anterior* white and grey substance of the spinal cord. The only other purely motor centre of the medulla oblongata, is the hypoglossal nucleus, which is developed from the *base* of the anterior grey substance. It is located apart from the olivary body, and is in the closest connexion with the vagus, spinal-accessory and glassopharyngeal nuclei with which it is destined to cooperate in reflex actions. Although distant from the olivary body it is, however, connected with it by a remarkable band of fibres.

(86) It it probable that the olivary bodies are not only the centres through which different movements are coordinated for expressing the passions and emotions, but that they are the motor centres through which different movements are effected by sudden, violent, or peculiar impressions on the special senses; for they are intimately connected with all the sensory ganglia of the medulla,—with the grey tubercle (trigeminus), the vagus nucleus, the post-pyramidal and restiform nuclei (auditory ganglia), the corpora quadrigemina (optic ganglia) through the fillet, and not improbably with the parts about the root of the olfactory bulbs, since I have traced the olivary columns nearly to the anterior perforated space.

(87) I have a few remarks to make on paralysis of the facial and abducens nerves.

* See my "Medulla Oblongata," Plate XV. fig. 24, Philosophical Transactions, 1858.

When paralysis of the facial nerve depends on central lesion it is frequently associated with paralysis of the abducens. Sometimes both nerves are paralyzed on one side, and one of them on the other; and sometimes, but more rarely, both nerves are paralyzed on each side. I have seen two cases of this kind. One of them was in the practice of Dr. HUGHLINGS JACKSON. Now, when we consider that both the facial and abducens nerves are connected with the same nucleus on each side of the floor of the fourth ventricle (see fig. 51, Plate XIII. and fig. 65, Plate XIV.), it is evident that a tumour pressing on this part, or any morbid process that injured it, would paralyze at the same time both the facial and abducens nerves; and if the lesion or foreign body extended across the ventricle to the other side, a bilateral paralysis to a greater or less extent would be the result. Dr. WILKS had under his care a little girl four years old, with paralysis of the right facial nerve and of both sixth nerves. The child's arms and legs did not appear to be much affected, but the left arm and leg were a little weaker than the right. On post-mortem examination by Dr. WILKS, a tumour about the size of a large walnut was found to occupy the pons Varolii, and more on the right side than the left. On opening the fourth ventricle, the tumour was seen to project into its cavity, and thus all natural appearance of this part was gone.

(88) I might dwell upon other points in this paper that may serve the purpose of the physiologist and pathologist, and which will probably be noticed by the reader, but I shall now conclude with a few words on the importance of combining together anatomy, experiment, and pathology in physiological investigations. A great physiologist, who conducted a large number of his researches by means of experiment, at length arrived at the conclusion, which he expressed in a paper read before the Royal Society, that anatomy is better adapted for discovery than experiment. "Experiment," he observes, "may take a colour from the preconceived idea, but the accurate investigation of the structure will not deceive us"*. The truth, however, appears to be, that anatomy and pathology, no less than experiment, are liable to deceive, and that neither of them, alone, is sufficient for the purposes of the physiologist. In attempting to determine the function of a particular part, pathology must be employed with great caution, when other parts of the same complex organ are at the same time affected by disease. The many contradictory results obtained by different experimentalists on the same subject are so frequent that this method of investigation cannot be trusted alone. But experiment will be more accurate and precise just in proportion to the accuracy of our knowledge with regard to the structure and relations of the parts on which the experiments are made. Moreover, even if the anatomist cannot immediately draw any physiological conclusions from his observations, those observations may suggest and guide experiment; and with this end in view, the philosophical observer will direct the course of his anatomical investigations. If, therefore, the experimentalist has made no original researches into the structure and relations of parts on which he purposes to operate, he must, if he wishes to avoid error, make himself thoroughly acquainted with the minute details of

* Sir CHARLES BELL, Nervous System.

structure supplied by the anatomist. From a want of this information serious blunders have been frequently made; for in dividing even a small part, particularly of the medulla oblongata, the operator may injure other parts, with which, as we have abundantly seen, it is so closely connected. LORRY and SERRES divided the medulla oblongata through the olivary bodies, and the latter anatomist concluded that the instant death of the animal was due to injury of those bodies; but if he had known that he had cut through the nucleus of the vagus, which STILLING had the merit of pointing out, his conclusion would of course have been different. On the other hand, the anatomist should make himself acquainted with the labours of the experimentalist, and pursue his researches by the light which they afford. It is in this way that observation, experiment, and induction alternately enlarge or enlighten the field of research and point out each other's path.

APPENDIX (added during the printing of the Paper).

On the Method of making the Preparations.

The method which I introduced some years back (1851) for rendering sections of the brain and spinal cord transparent and preserving them in Canada balsam, has been generally adopted both in Europe and America. The *principle* of the method is this: given a section of opake nervous substance that has been hardened in a fluid not miscible with Canada balsam; to render that section transparent and permeable by Canada balsam *without drying it.* One of the fluids which I employed in the process was oil of turpentine. The whole process may be described as follows.

The spinal cord or medulla oblongata is to be cut into pieces of from half an inch to an inch long and hardened in a solution of chromic acid, composed of one part of the crystallized acid to two or three hundred parts of water*. To this solution I generally add a small quantity of bichromate of potash, which brings out the nuclei of the nerve-cells more distinctly, and causes the grey substance to take the colour of carmine more brightly. At the end of three or four weeks the medulla is in a condition fit for making thin sections by means of a razor or other sharp knife wet with spirit of wine. If the sections are to be coloured with carmine, the ammoniated solution of this substance should be previously filtered, and the sections should be washed free from the spirit used in cutting them, before they are placed in the carmine solution, for spirit readily precipitates the carmine in the form of granules. When sufficiently coloured the sections should be again washed in water, and then soaked in strong spirit for a few minutes to expel the water. Sometimes a few drops of acetic acid may be added with advantage†. On removing them from the spirit, the sections, if thin, are to be floated on the surface of pure oil of turpentine, which will ascend from below and replace the spirit

* For the convolutions of the cerebrum and cerebellum the solution must be much weaker.

† Mr. ADAM ADDISON, late of the Montrose Royal Asylum, sometimes adds a few drops of a saturated spirituous solution of chloride of sodium instead of acetic acid.

that evaporates from their upper surfaces. In a short time, sometimes almost immediately, they will become quite or nearly transparent, when they are to be removed to glass slides on which a little Canada balsam has been dropped. Before they be finally covered with thin glass they should be examined under the microscope, and if all their parts be not perfectly transparent or *distinct* and well defined, a little turpentine and Canada balsam should be alternately dropped on them from time to time until the requisite effect be produced. If the sections be thick, I find it best, instead of floating them on the turpentine, to place them in a shallow vessel the bottom of which is simply wet with turpentine, which then ascends from below while the spirit evaporates from above. Before using the turpentine I also frequently remove a large portion of the spirit by placing the sections for a minute on fine blotting-paper. The process may be further hastened by the following plan: place the section on a glass slide, after the spirit has been partially removed by blotting-paper; drop on it some turpentine, and then tap it gently with the end of the finger, repeating these steps alternately until transparency be produced.

By any one practised in this method, a thin section, after having been coloured, washed, and steeped in the strongest spirit, may be rendered perfectly transparent and fit for mounting in Canada balsam in the course of eight or ten minutes; and a section of moderate thickness in fifteen minutes. But many observers have complained that the use of turpentine renders the process slow, and they have therefore substituted for turpentine a variety of other media, as oil of cloves, creosote, carbolic acid, which so much resembles it, &c. Creosote is that which is now most used on the Continent. In this country another modification of my method has been introduced by Dr. CHARLTON BASTIAN. The section having been coloured, washed, and saturated in spirit, is placed on a drop of carbolic acid, instead of turpentine, in the centre of a glass slide. In less than two minutes it is rendered transparent; and when this is accomplished (having got rid of any excess of carbolic acid), he pours over it three or four drops of chloroform, in which the specimen is allowed to remain for two minutes. The superfluous chloroform is then poured off, whilst one or two drops of a solution of Canada balsam in chloroform are dropped over the specimen, and the covering glass is then quickly applied. The whole process extends over ten minutes*. Although these modifications may possess some advantages in point of expedition, the *principle* is the same as that of the original method which I introduced. The preparations so made are certainly not in the slightest degree superior to my own.

GERLACH now hardens the cord in a solution of bichromate of ammonia of the strength of one to two per cent. The sections are then put into a solution of 1 part of chloride

* Journal of Anatomy and Physiology, November 1867. Dr. BASTIAN here speaks of my original process with turpentine extending over a space of four or five hours! If this were the case it would have been impossible for me to make the thousands of preparations I have made, and to have done the work I have done by means of them. However, for Dr. BASTIAN's satisfaction, I rendered a section transparent, and fit for mounting in Canada balsam, in his presence, in the course of fifteen minutes.

of gold and potassium to 10,000 parts of water slightly acidulated either with vinegar or hydrochloric acid, for ten or twelve hours, when the white substance becomes of a pale lilac (blass lilla), while the grey substance is scarcely coloured. They are then placed in a mixture of 1 part of hydrochloric acid to 2000 or 3000 parts of water for a few minutes. After this the sections are steeped for about ten minutes in a mixture of 1 part of hydrochloric acid to 1000 parts of 60 per cent. alcohol, and then for some minutes in absolute alcohol; after which they are made transparent by means of creosote and put up in Canada balsam*. This is rather a complicated process.

Explanation of the Plates.

PLATE VIII.

Fig. 1. Transverse section of the lower end of the human medulla oblongata at the points of the anterior pyramids:—*b c*, the posterior column; *d*, the posterior part of the antero-lateral column; *e*, the caput cornu posterioris, or expanded extremity of the posterior horn; *d'*, network of fibres and blood-vessels, mixed with small nerve-cells, in the deep portion of the lateral column, between the anterior and posterior horns; *t*, central grey substance behind the canal; in front of the canal is seen the commencing decussation of the anterior pyramids; *z*, the anterior median fissure.

Fig. 2. A similar section a little higher up. The decussating fibres of the anterior pyramids are much more numerous: V is a portion of the anterior column of the spinal cord forming the non-decussating part of the anterior pyramid of the same side.

Fig. 3. The same, a few sections higher up:—*f*, *d'*, *d'*, bundles of fibres coming from the lateral column and lateral grey substance to form the anterior pyramid of the opposite side; *b*, *b'*, rudiments of the posterior pyramid.

Fig. 4. The same, still higher up:—*f'*, anterior cornu; *o*, conical eminence from the outer part of the cervix cornu forming the rudiment of the grey nucleus of the restiform body; *b*, *b*, posterior pyramids containing grey substance derived from the inner part of the cervix cornu on each side of the posterior median fissure.

Fig. 5. Similar section at the upper part of the decussation of the anterior pyramids:—*b'*, grey nucleus of posterior pyramid very much enlarged; *e*, caput cornu posterioris (grey tubercle of Rolando), also greatly enlarged; *o*, inner grey nucleus of restiform body much increased in size; *c'*, its outer grey nucleus; *k*, posterior median fissure; *t*, rudiment of central spinal-accessory nucleus; *t'*, rudiment of hypoglossal nucleus; *f*, remains of anterior cornu of spinal cord; *n''*, bundles of fibres coming from the restiform nucleus (*o*) and from

* Zur Anatomie des Menschl. Rückenmarks. *Medecin. Centralbl.* Nos. 24, 25.

the postpyramidal nucleus (b') to the opposite anterior pyramid (y'), those from the opposite side decussating each other in front of the canal. The anterior pyramids have now ceased to derive their fibres from the lateral columns of the cord.

Fig. 6. Similar section just above the decussation of the pyramids. The restiform nucleus (o), the postpyramidal nucleus (b'), and the grey tubercle of ROLANDO, e (caput cornu posterioris), are still further enlarged. The decussating fibres from b o, the postpyramidal and restiform nuclei, instead of entering the anterior pyramids y y, now proceed to the lower ends of the olivary bodies (W, W). The spinal-accessory nucleus (t) and the hypoglossal nucleus (t') are still further developed. r is the spinal-accessory nerve.

Fig. 7. A similar section of the medulla nearer the point of the calamus scriptorius. The inner and outer restiform nuclei (o and c') are much enlarged, and the white substance (c) of the restiform body is overlain by the posterior pyramid (b) and its contained nucleus (b'), also increased in size. The hypoglossal nerve (x) is seen to enter its nucleus (t'), which, like the spinal-accessory nucleus (t) is further developed. The olivary bodies (W) increase in size; s is the *antero-lateral* nucleus.

Fig. 8 is a similar section just below the calamus scriptorius. The posterior median fissure has just begun to open into the fourth ventricle. The grey nuclei of the posterior pyramids and restiform bodies nearly coalesce, the dotted line, b'' (on the right side), defining the limits of each. The olivary bodies are much increased in size.

Fig. 9. A similar section through the fourth ventricle, a little above the calamus scriptorius. The grey nuclei of the posterior pyramids and of the restiform bodies on each side have entirely coalesced. The spinal-accessory nucleus has now become the *vagal* nucleus (g), und is more distinctly separated from the hypoglossal nucleus (t'). At U is seen a small group of cells forming the lowest end of the nucleus of the motor root of the trigeminus.

Fig. 10. Similar section of the medulla on a level with the *upper* roots of the vagus nerve. The hypoglossal nucleus (t') is brought to the surface of the ventricle, while the vagal nucleus (g) is partly sunk between it and the rudiment of the inner auditory nucleus (i) which is developed out of the posterior part of the vagal nucleus (g) and the inner part of the posterior pyramid (b, fig. 9). The convolutions of the olivary bodies are more numerous than in fig. 9.

PLATE IX.

Fig. 11. Posterior view of human medulla oblongata:—a, its lower end; b b', the posterior pyramid of right side; c, right restiform body; d, lateral column; e, grey tubercle of ROLANDO, or caput cornu posterioris; g, pyriform nucleus of vagus

nerve; *t'*, column at side of median furrow constituting the hypoglossal nucleus.

Fig. 13. Side view of the same:—W, olivary body; *y*, anterior pyramid; A, arciform fibres.

Figs. 15 to 21 represent transverse sections of the medulla oblongata of the Monkey; fig. 15, section just below the point of the anterior pyramids. The same letters signify the same parts as in figs. 1 to 10 of the human medulla, Plate VIII.

PLATE X.

Fig. 22. Transverse section of the posterior part of the right lateral half of the medulla oblongata of the Monkey at the level of the highest roots of the vagus nerve.

Fig. 23. Similar section of the whole right lateral half of the medulla:—*i*, the inner auditory nucleus; *c' o*, the outer auditory nucleus, pierced by numerous longitudinal bundles of fibres (represented by the dark masses); *t''*, nucleus of the lower roots of glossopharyngeal nerve (*g*).

Fig. 24. Longitudinal and horizontal section of the left half of the posterior part of the human medulla oblongata:—*b b'*, white and grey substance of the posterior pyramid; *o*, inner grey substance or nucleus of restiform body; *c'*, its outer nucleus; *g*, vagal nucleus; *i*, inner auditory nucleus; *c' o*, outer auditory nucleus, formed by the fusion of the restiform and postpyramidal nuclei.

Fig. 25. Transverse section of the spinal-accessory and hypoglossal nuclei of the left side, at the level of the lower end of the olivary body:—E, bottom of the posterior median fissure; H, group of cells constituting the anterior portion of the spinal-accessory nucleus; *r*, the spinal-accessory nerve; the remainder of the figure behind this group is the posterior division of the spinal-accessory nucleus; B, columns of cells and longitudinal fibres, with transverse fibres decussating across the middle line with those of opposite side; below these are decussating fibres from the anterior division (H) of the nucleus; *h*, central canal lined by columnar epithelium; J, hypoglossal nucleus; J'', fan-shaped set of fibres converging to decussate across the raphé (F); K', small column of cells and longitudinal fibres, ascending and increasing as it ascends, between the hypoglossal and spinal-accessory nuclei to the "fasciculus teres;" *x*, roots of hypoglossal nerve.

Fig. 26. Nerve-cells from the outer restiform nucleus of the Monkey; magnified 220 diameters.

Fig. 27. Oblique-longitudinal section of the medulla oblongata, carried along the line L *t*, fig. 5, and extending as high as fig. 8:—*n n'* is the slender column of the vagus and spinal-accessory nerves; *t t* is vagus and spinal-accessory nucleus; the dark masses at *n''* represent the cut-ends of the transverse bundles of fibres

shown at n'', fig. 5, and coming from the postpyramidal and restiform nuclei to decussate into the anterior pyramids.

Fig. 28. Left lateral half of the grey substance of the medulla, a little below fig. 5, and where the *lower* roots (r) of the spinal-accessory nerve begin:—t, lower end of the special nucleus of the *upper* roots of the nerve; t', lower end of the special nucleus of the *upper* roots of the hypoglossal nerve, at the side-front of the canal; x, *lower* hypoglossal roots arising from a group of cells in the remains of the anterior cornu, f'; o, restiform nucleus; b', postpyramidal nucleus. On the left of $t\,t'$ are seen the last traces of the curved bundles of fibres which the anterior pyramids in their course downward send into the posterior grey substance (see n'', fig. 5).

Fig. 29. Transverse section of the grey substance of the lowest end of the medulla oblongata at the point of the anterior pyramids:—e'', posterior roots of first cervical nerves extending forward into the antero-lateral grey substance, to the part where the lowest fibres (f') of the anterior pyramids are connected with it. The same part is also connected with the lower roots of the spinal-accessory nerve (r), which is seen to traverse the lateral grey substance and reach the anterior cornu.

Fig. 30. Longitudinal section of part of the human medulla:—t'', glossopharyngeal nucleus; $n\,n$, slender longitudinal column; g, roots of the glossopharyngeal nerve running partly longitudinally along this column; i, the inner auditory nucleus.

Fig. 31. Longitudinal and horizontal section along the floor of the fourth ventricle, at the dotted line, fig. 32, through the hypoglossal nucleus (J), the vagus nucleus (H, H$'$), and the slender longitudinal column (n). From the large multipolar cells of the hypoglossal nucleus (J, J$''$, fig. 31), numerous processes extend outward, between longitudinal bundles of fibres, into the inner and outer portions (H, H$'$) of the vagus nucleus. n is the slender column of longitudinal fibres, continuous with some of the transverse fibres of the vagus nucleus.

PLATE XI.

Fig. 33. Transverse section of the medulla oblongata of the Cod-fish, at the point of the calamus scriptorius:—1, 1, the anterior portion of the medulla; 2, 2, cut-ends of large bundles of fibres at its surface; 3, group of large multipolar cells in its centre; 4, cut-end of column of longitudinal fibres in front of the canal, 6; 5, large group of multipolar cells at the side and front of the canal; 7, fibres radiating from it to the surface (on left side); 8, lower root of vagus nerve arising from it, and joining the other root, 9, which arises from the inner and posterior part of the medulla (10, 10) at the side and behind the canal. The group of cells (5) occupies the position of the hypoglossal nucleus

in mammalia. 11, restiform body; 12, grey substance within it; 13, large band of fibres arising from it, and crossing obliquely to the anterior part of the opposite side of the medulla, decussating with its fellow; 14, trunk of the vagus nerve.

Fig. 34. Group of multipolar cells giving origin to the anterior root (8) of the left vagus nerve, as shown in preceding figure:—6, left wall of the canal lined with epithelium; 13, 13, decussating band of fibres; magnified 100 diameters.

Fig. 35 represents a transverse section of the right anterior pyramid (*y*) and olivary body (W) of the Cat. The olivary body consists of three separate portions.

Fig. 36 represents a transverse section of the right lateral half of the medulla of one of the higher Apes. The structure is peculiar. The highly developed and convoluted olivary body (W) is imbedded in the anterior pyramid, and a separate column (*d*) is on its outer side.

Fig. 37. Transverse section of the right anterior pyramid and olivary body of the Orang Outang. The olivary body largely developed, and its lamina thrown into numerous folds.

Fig. 38. Transverse section of the floor of the fourth ventricle of the left side, from the human medulla, on a level with the upper roots of the vagus nerve:—J, upper part of column of large multipolar cells constituting the hypoglossal nucleus. Some of the cells on its outer side are elongated outward, and send their processes in the direction of the vagus nucleus (*t*, H) and of the nerve (*g*). It is immediately overlain by the column K′, which consists of smaller cells and numerous longitudinal fibres, and which we saw lower down, much reduced in size, in fig. 25. This column is in its turn overlain by the vagus nucleus, between which and the hypoglossal nucleus (J), it is almost entirely imbedded. If we suppose the lower part of the central canal (*h*) in fig. 25 to open into the floor of the fourth ventricle, and the parts on its left to be thrown aside outward, the three nuclei (J, K′, H, fig. 25) will assume the position which they occupy in fig. 38.

Fig. 39. Similar section a little higher up, on a level with the roots of the glossopharyngeal nerve. The hypoglossal nucleus has almost wholly disappeared, a few small cells only (J, J′) remaining with a few nerve-roots. T, dark oval group of cells, increased in size from fig. 38; K′, in the *fasciculus teres*, much increased in size; *i*, inner nucleus of auditory nerve; *t*, glossopharyngeal nucleus with its club-shaped group of cells. It is overlain by the junction of the auditory nucleus (*i*) with the *fasciculus teres*; U, lower end of column of large multipolar cells constituting the nucleus of the motor root of trigeminus nerve. It is connected, by a plexiform system of fibres (U′), with both the *fasciculus teres* and the glossopharyngeal nucleus, especially the latter; *n*, slender longitudinal column of fibres.

Fig. 40. Similar section still higher up. The inner auditory nucleus (*i*) has become

continuous with the fasciculus teres (K′), and increased in size:—Q, Q′, cut ends of oblique *lineæ transversæ*; T, the two oval groups of nuclei much increased in size.

Fig. 41. One lateral half of the human pons Varolii and medulla seen from its under side:—Y, cut middle peduncle; X′, fibres winding round it from fourth ventricle; *c*, restiform body; Z″, band of fibres winding round it from fourth ventricle, to side of pons; X, facial nerve; Z, auditory nerve; Z′, cut end of fifth nerve; *w*, olivary body; Y, anterior pyramid; W W′, pons Varolii.

PLATE XII.

Fig. 42. Transverse section of the posterior portion of the human medulla on left side:—*c*, restiform body; *c′ o*, outer auditory nucleus; *i*, inner auditory nucleus; K′, fasciculus teres; S, a network containing several large multipolar cells, with intervening longitudinal bundles beneath the *fasciculus teres*, and in the place where the hypoglossal nucleus ends; H, nucleus of glossopharyngeal nerve; *n*, slender columnar of longitudinal fibres, now containing a great number of nuclei, and connected with glossopharyngeal nerve (*g*); U, nucleus of motor root of trigeminus; *e e e e*, cut end of descending root of trigeminus at extremity of çaput cornu posterioris, or grey tubercle; P, posterior auditory nerve; Q Q′, a large stria medullaris winding over the surface of the ventricle, and passing from behind forward along one side of raphè, R.

Fig. 43. Posterior half of the left side of the human medulla oblongata, just below the pons Varolii:—W, upper end of olivary body; *e*, grey substance of grey tubercle overlain in front by the dark cut ends of the bundles of the descending root of the trigeminus; *i*, inner auditory nucleus; *c′ o*, outer auditory nucleus; P P′, posterior auditory nerve arising from both these nuclei, and from radiating fibres (*p′*) of restiform body. A network of fibres proceeding from the outer auditory nucleus (*c′ o*) crosses the grey tubercle (*e*) to the central part of the medulla and to the raphè; in the higher Apes these fibres are very numerous and distinct (see fig. 36, Plate XI.).

Fig. 44. The same, a few sections higher up:—Z, clusters of small cells on the inner side of the ganglionic enlargement of auditory nerve; Q′, Q, cut ends of striæ medullares.

Fig. 45. Side view of the human medulla oblongata, pons, tubercula quadrigemina, and crus cerebri:—*c*, restiform body entering cerebellum; P″, anterior auditory nerve; one portion of it ascends with restiform body to cerebellum; C′, trigeminus; E, superior peduncle of cerebellum; *f′*, fillet; *q′*, testis.

Fig. 46. Transverse section of left lateral half of the medulla oblongata of a child five years old, at the anterior auditory nerve:—K′, fasciculus teres, connected by numerous plexiform fibres with U, the motor nucleus of trigeminus; *e*, grey

tubercle of ROLANDO, having in front the cut ends of numerous bundles of descending root of trigeminus inclosed in a beautiful network of fibres containing nerve-cells. The tubercle is connected with the motor nucleus (U) of trigeminus by fibres; *i*, upper part of inner auditory nucleus; *c′ o*, outer auditory nucleus, extending backward to the cerebellum; P″, the anterior auditory nerve, entering this nucleus at *c′ o*, beneath the restiform body. Both the nucleus, and the root of the nerve P″ are intimately connected with the outer side of the grey tubercle and with the network within it; *p′*, radiating fibres of restiform body in the middle peduncle; *p″*, *p‴*, arciform fibres from the same part extending round the olivary body; J′, corpus dentatum cerebelli.

Fig. 47. Dissected portion of human fourth ventricle of left side:—*c c′*, the restiform body or inferior peduncle of the cerebellum; *c‴*, middle peduncle of cerebellum; C″, large root of trigeminus; D′, its conical nucleus; P″, anterior division of auditory nerve; *i*, concavity left by removal of *inner* auditory nucleus beneath which P″ enters the *outer* auditory nucleus. The anterior and under portion of the trigeminal nucleus D′, connected with the point of the fillet (*f*), gives origin to the small or motor root (G′) of the trigeminus, which is separated from the large root (C″) by a small bundle of the middle peduncle (A′) coming from the pons. The larger root (C″) is separated from the anterior auditory nerve (P″) by a larger bundle of the middle peduncle coming from the pons; E′, superior peduncle rolled forward, exposing a thick and broad tract of grey substance (D″) extending obliquely upward beneath it from the conical nucleus (D′) of the trigeminus; F, loop of the facial nerve.

Fig. 48. Left lateral half of the medulla with part of the inferior vermiform process of the cerebellum from the Rabbit:—*e*, grey tubercle; *e″*, cut end of descending root of trigeminus in front of it; P″, anterior root of auditory nerve; *e‴*, cut ends of longitudinal fibres at root of grey tubercle, in connexion with fibres of anterior auditory root; *c′ o*, outer auditory nucleus giving origin to anterior root of auditory nerve; *i*, upper part of inner auditory nucleus; E′ E″, plexus of bundles, with intervening cells running through the lower part of superior peduncle to vermiform process (I′ I″); T″, longitudinal portion of loop of facial nerve; *s*, antero-lateral nucleus.

PLATE XIII.

Fig. 49. Transverse section of left lateral half of medulla oblongata of Cat, at level of auditory nerve:—P‴, under and whiter portion of nerve entering the outer auditory nucleus (*c′ o*); P′, bulbous portion crowded with nerve-cells; *e″*, descending root of trigeminus; *s*, antero-lateral nucleus connected with its opposite fellow of decussating fibres across the raphè.

Fig. 50. Transverse section of the fourth ventricle in Man on left side:—*g″ g‴*, super-

ficial grey layer covered with columnar epithelium; h'', median furrow of ventricle; Q'', principal nucleus of facial nerve; i, inner auditory nucleus.

Fig. 51. A similar section a little higher up, including the grey tubercle of ROLANDO:—g''', superficial grey layer of ventricle; T'', cut end of longitudinal portion of loop of facial nerve; Q'', principal nucleus of facial; q'', facial nerve; $e\,e'$, grey tubercle; $c'\,o$, remains of outer auditory nucleus; i, remains of inner auditory nucleus, sending fibres to Q''.

Fig. 52. Transverse section of fourth ventricle of Rabbit on left side.

Fig. 53 shows the course of the root of the facial nerve (q'') from without inward in the Sheep.

Fig. 54 shows the same in Man.

Fig. 55 represents a longitudinal section of loop of the facial nerve in the plane of its course, in Man: magnified 100 diameters.

Fig. 56 shows a transverse section of the fourth ventricle in Man, on the left side along the root of the facial nerve:—g'', superficial grey layer; g''', group of cells on its outer part; above this are the cut-ends of three blood-vessels in their sheaths; T'', cut-end of longitudinal portion of loop of facial nerve; h'', median furrow of ventricle; Q'', principal nucleus of facial nerve; q'', facial nerve; q''', grey streak in its middle, behind which is a blood-vessel and streaks of longitudinal fibres. The under portion of the nerve is seen entering the nucleus (Q''); its remaining fibres decussate with those of the superficial portion (l') of the nerve; the chief portion enter T'' and become longitudinal along the loop; the rest pass in front of the loop to the raphè beneath the median furrow (h''); V', the sixth or abducens nerve, breaking up into a network of bundles enclosing longitudinal fasciculi, and becoming connected with the inner part of Q''.

PLATE XIV.

Fig. 57. Horizontal and longitudinal section along the left side of floor of the fourth ventricle in Man, extending from the upper end of the hypoglossal nucleus (J) to the lower end of the facial nucleus (Q''):—$c'o$ is the outer auditory nucleus; e', the base of the grey tubercle or caput cornu posterioris; Q'', the facial nucleus; T'', lower end of the loop of facial nerve, diverging and curving outward and downward round Q''; g''', the superficial grey layer of ventricle; h'', the median furrow of ventricle overlying the raphè. At the lower end of the figure, H is the vagus nucleus; J, the cells of the upper and tapering end of the hypoglossal nucleus; J', a longitudinal plexus of fibres running from the facial nucleus (Q'') to the hypoglossal nucleus (J).

Fig. 58. A similar horizontal-longitudinal section a little deeper from the surface of the ventricle. Figs. 59 & 60 are transverse sections of the medulla at the

upper and lower ends of the longitudinal section, after it was removed. In figs. 58 & 59, the upper lines of section correspond:—F is the raphè immediately below the median furrow of the ventricle; V, the white column between the raphè and the entrance of the abducens (V′) into the nucleus (Q″); *e*′ is the base of the grey tubercle; *c*′*o*, the outer auditory nucleus. The *lower* line of fig. 58 corresponds to the *upper* line of the transverse section, fig. 60, in which J is the anterior portion of the hypoglossal nucleus; V the white column between it and the raphè; O″, the white olivary column lying between it and the vagus nucleus (H); *n*, the slender longitudinal column of the vagus; *c*′*o*′, the lower end of the outer auditory nucleus, formed by the grey substance of the restiform body and posterior pyramid. The white column, V, (fig. 59), between the raphè (F) and the entrance of the abducens nerve into the nucleus (Q″) is continuous in fig. 60 with the white column (V) between the *hypoglossal* nucleus (J) and the raphè.

Fig. 61. Transverse section of part of the left lateral half of the medulla oblongata of the Rabbit, through the trapezium:—*e*, grey tubercle; *e*″, descending root of the trigeminus; *q*″, facial nerve; *p*′, *p*″, arciform fibres running forward and inward through the trapezium in front of the superior olivary body, *s*″.

Fig. 62. Transverse section through the whole left lateral half of the medulla at the level of the facial and abducens nerves, from the Orang Outang:—Q″, common nucleus of facial and abducens nerves; T″, descending portion of loop of facial. Transverse fibres of trapezium (*p*″) more concealed by the enlarged pyramid (*y*).

Fig. 63. A similar section from Man. Here the transverse fibres of the trapezium (*p*″) are completely enclosed and concealed by the anterior pyramid and pons Varolii.

Fig. 64, A. Atrophied nerve-cells from the olivary bodies, in a case of paralysis; magnified 350 diameters.

Fig. 64, B. Cells from a healthy olivary body; magnified 350 diameters.

Fig. 65. Transverse section through the fourth ventricle on a level with the facial and abducens nerves, from a child: the letters indicate the same parts as in other figures.

Fig. 1.

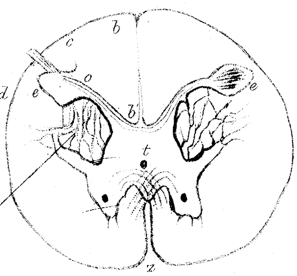


Fig. 2.

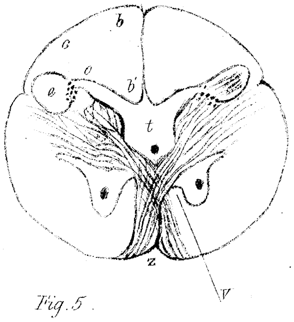


Fig. 3.

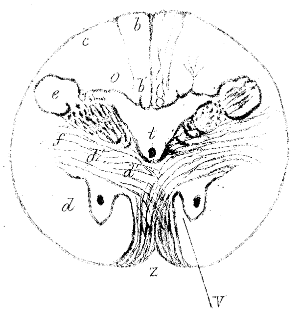


Fig. 4.

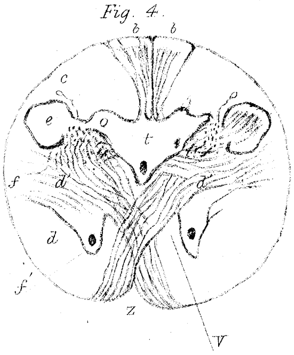


Fig. 5.

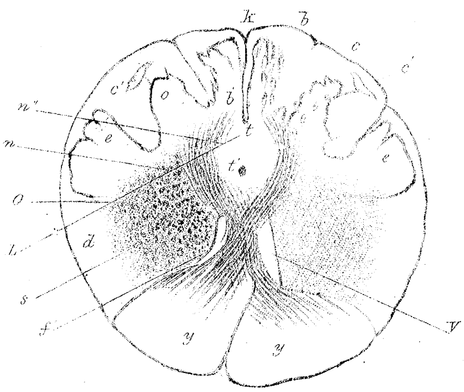
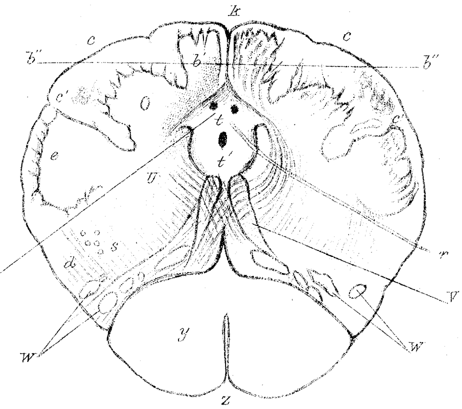


Fig. 6.



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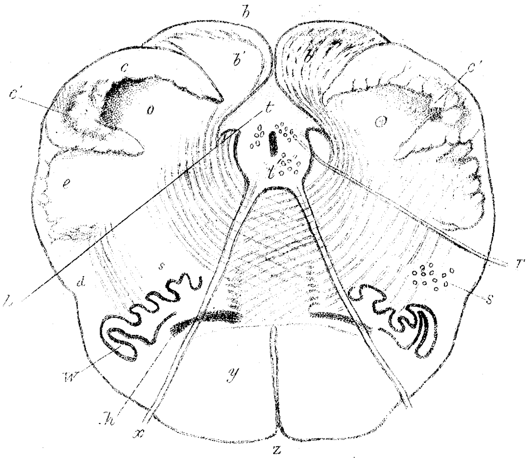

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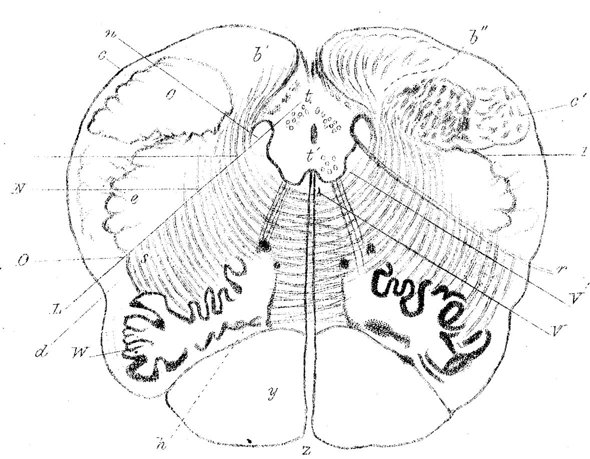

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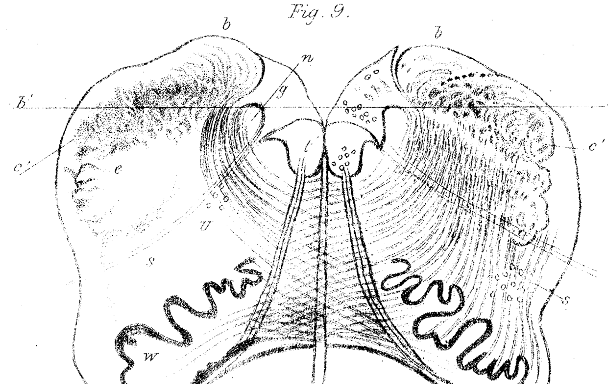

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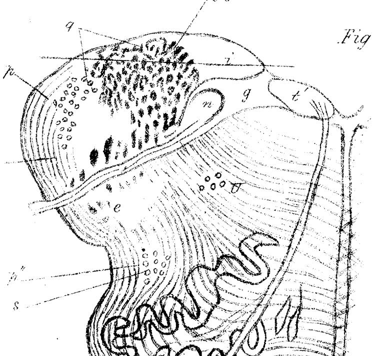

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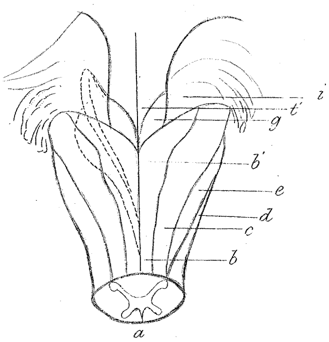
Fig. 11.



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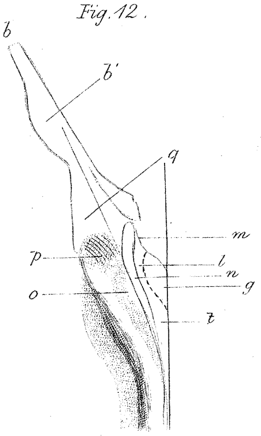

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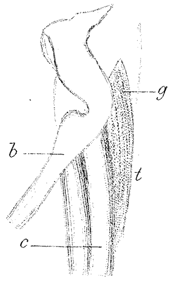

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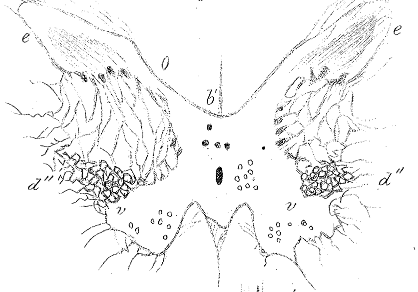

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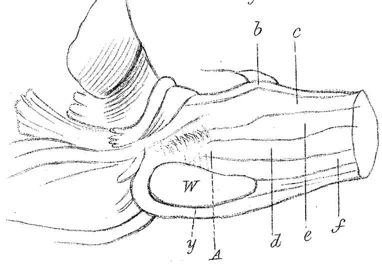

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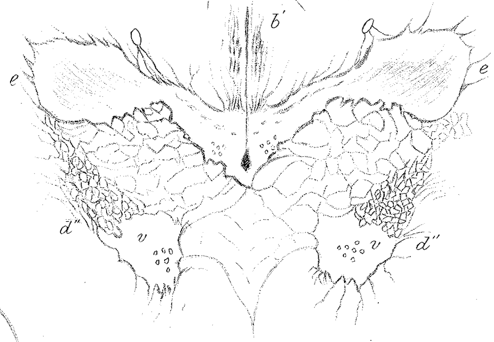

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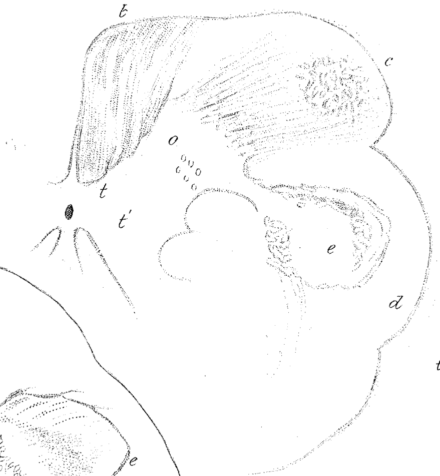

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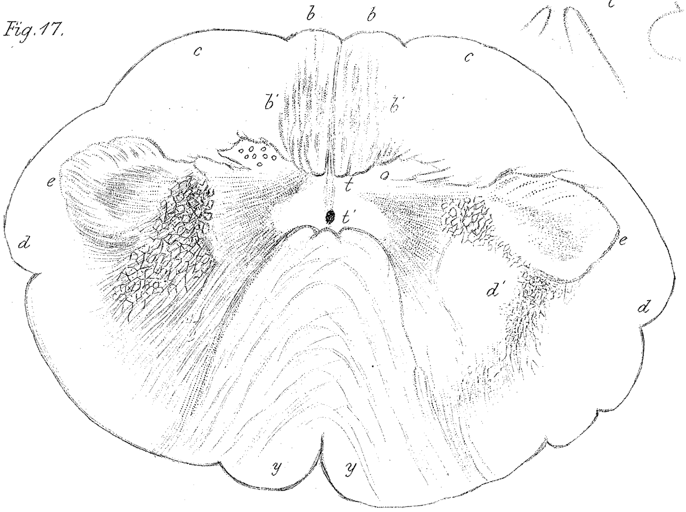

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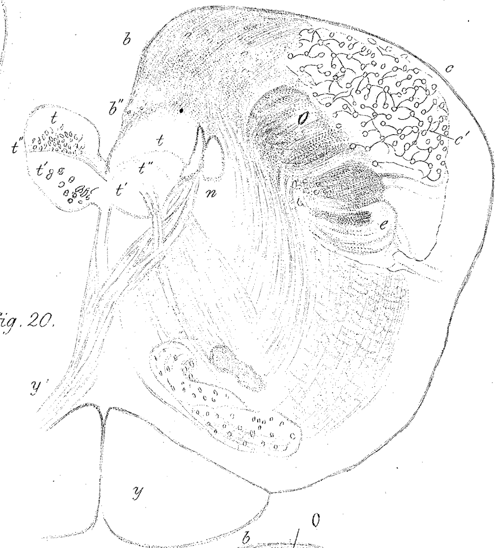

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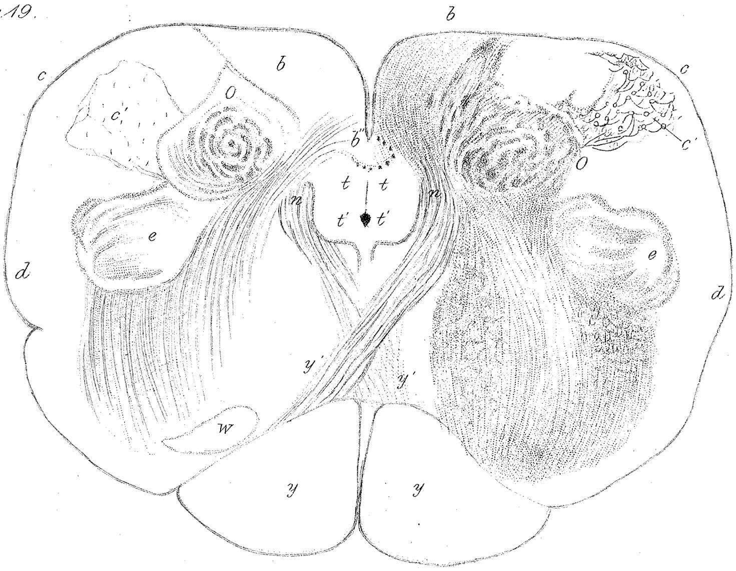

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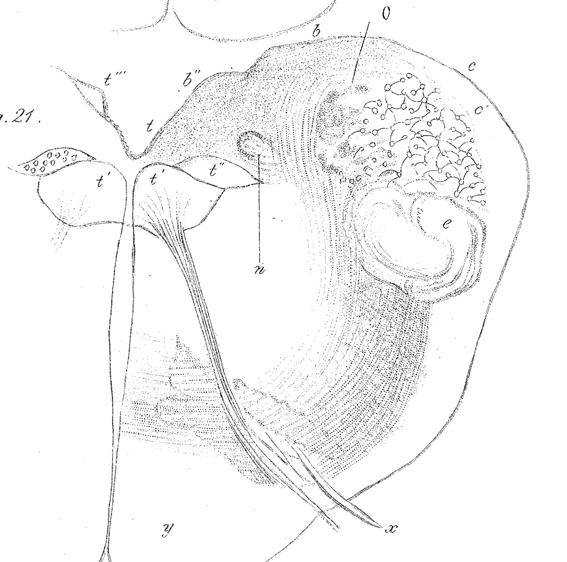

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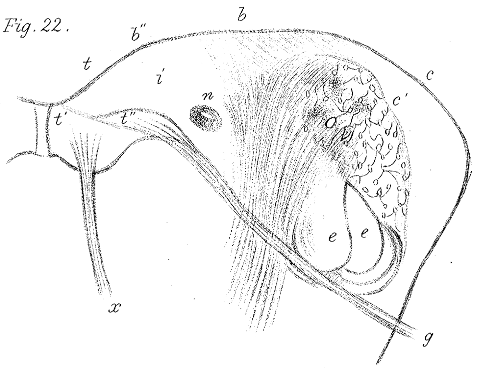
Fig. 22.



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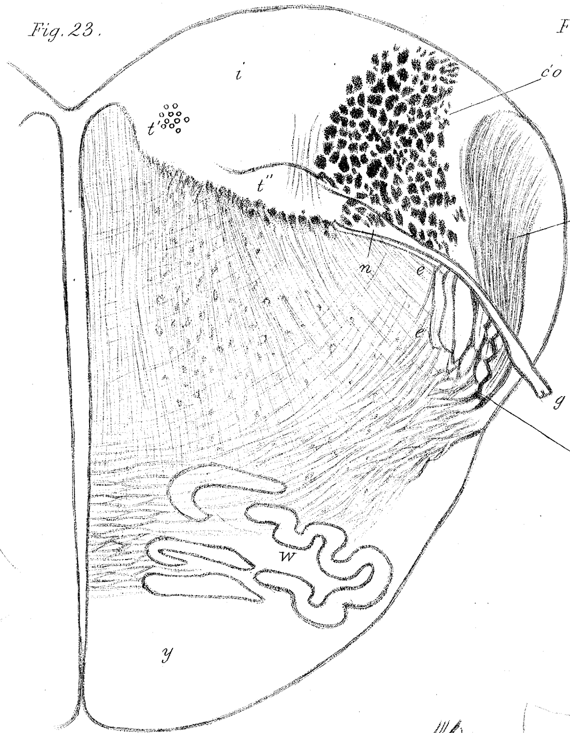

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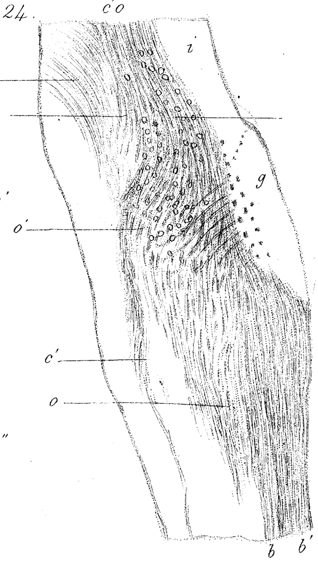

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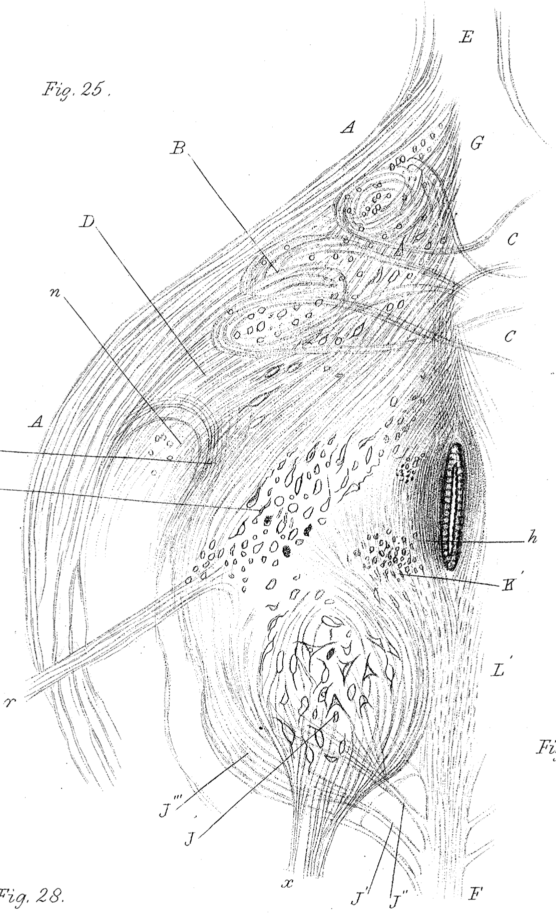

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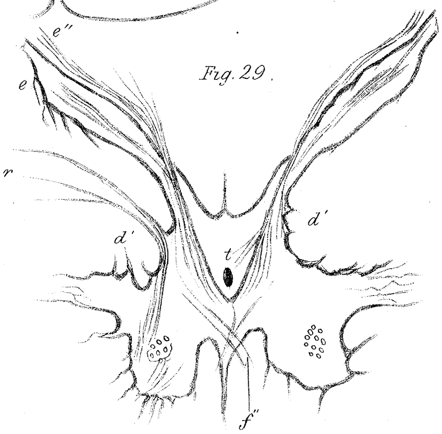

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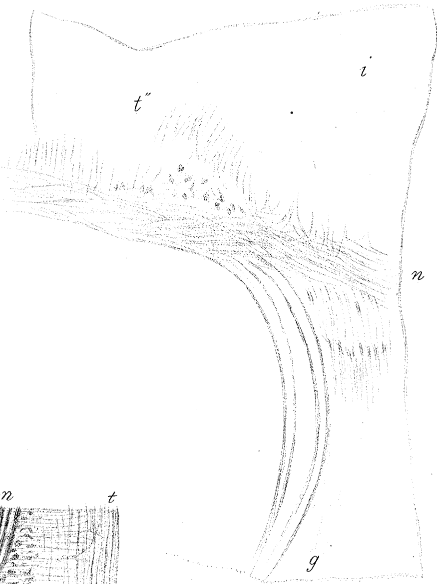

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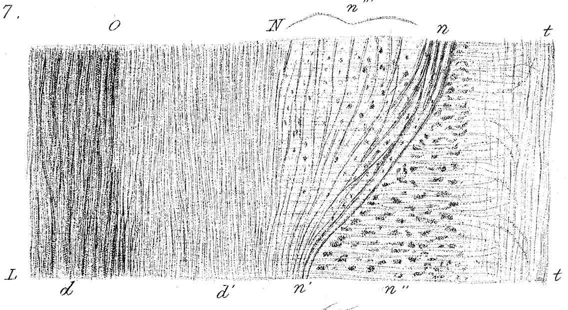

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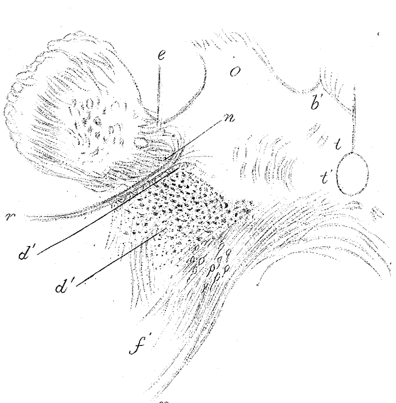

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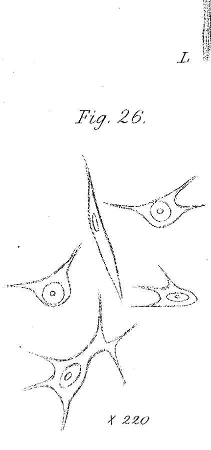

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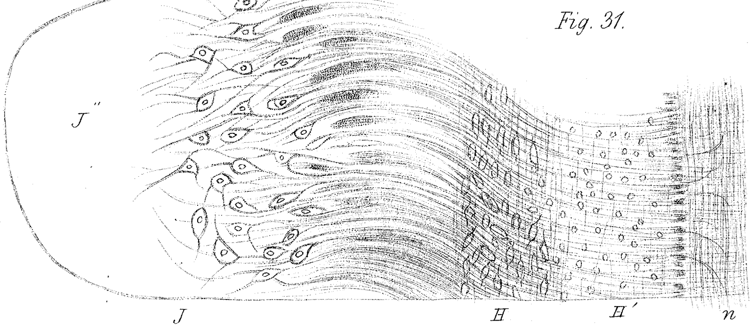

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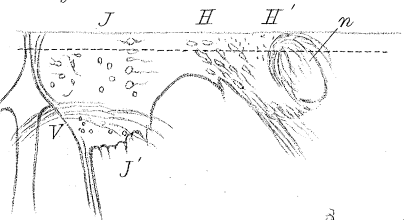
Fig. 32.



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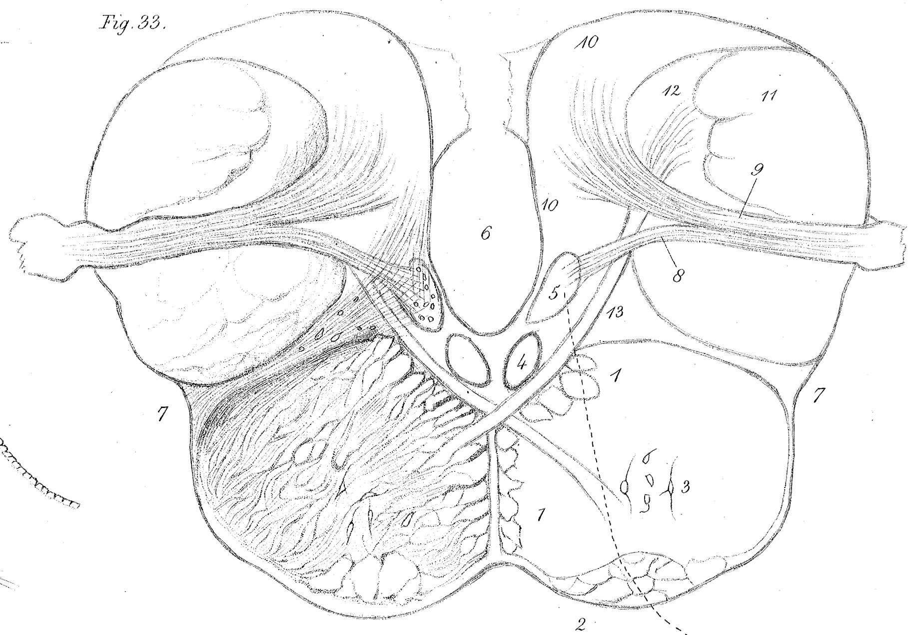
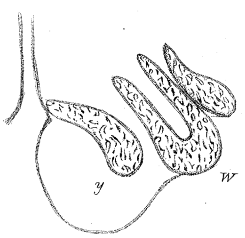


Fig. 34.

Fig. 35.



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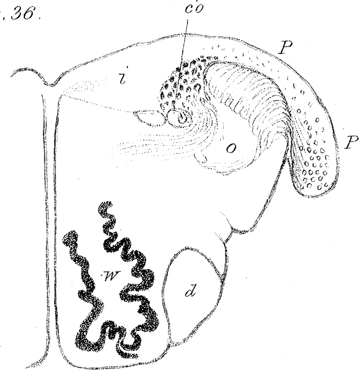

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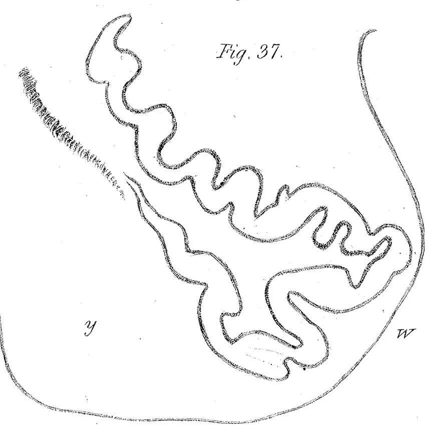

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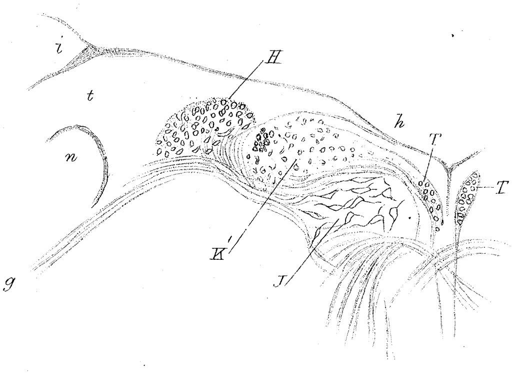

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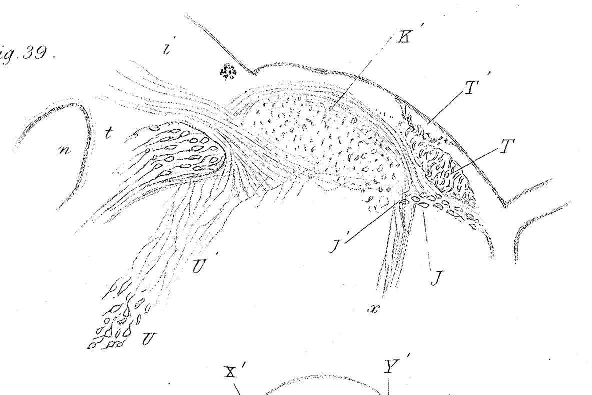

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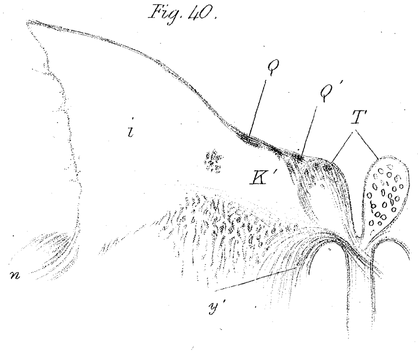

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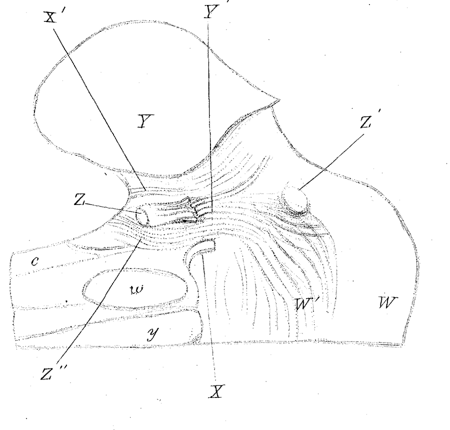

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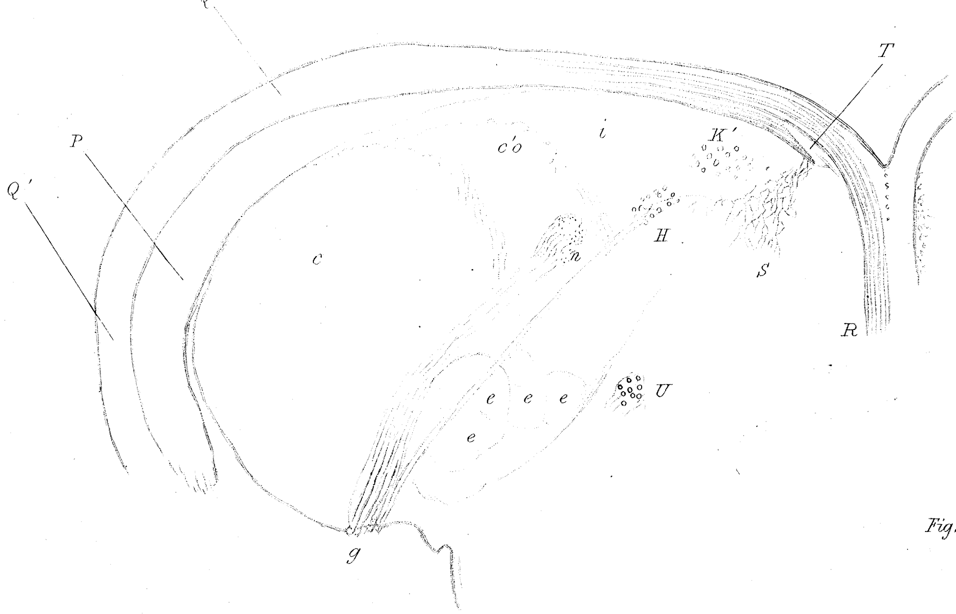
Fig. 42.



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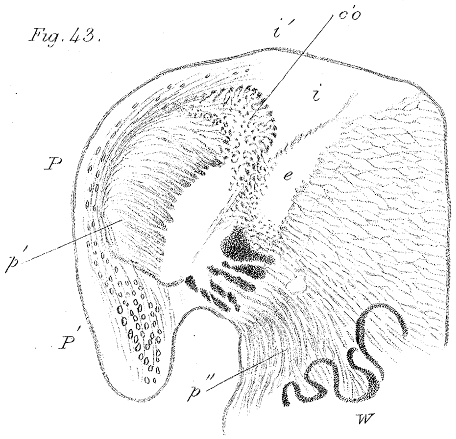

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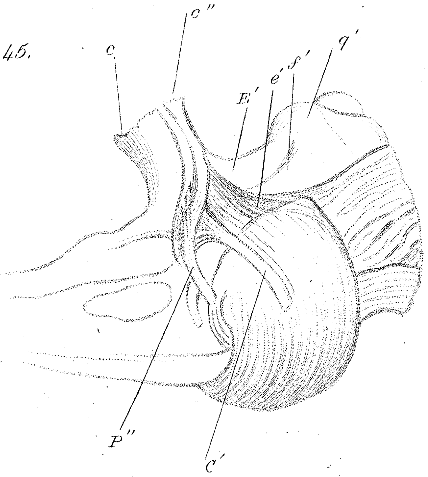

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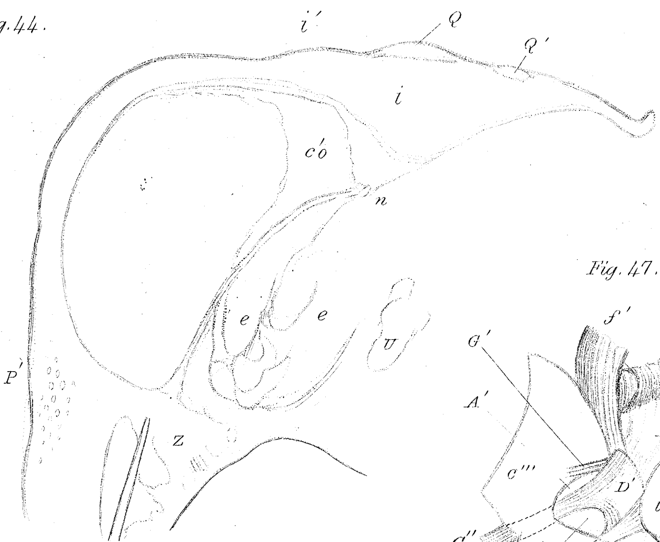

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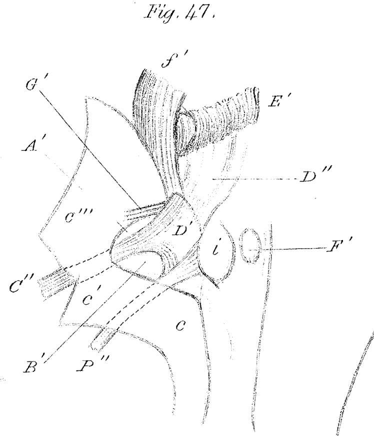

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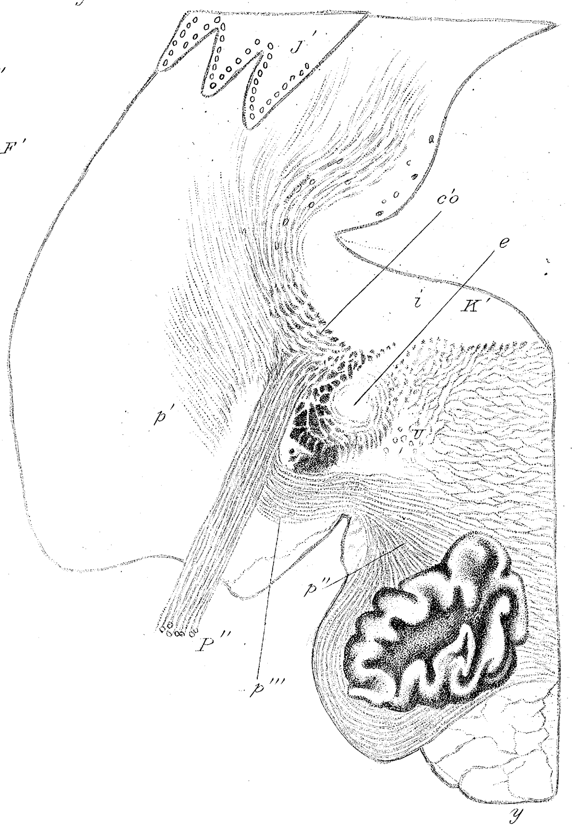

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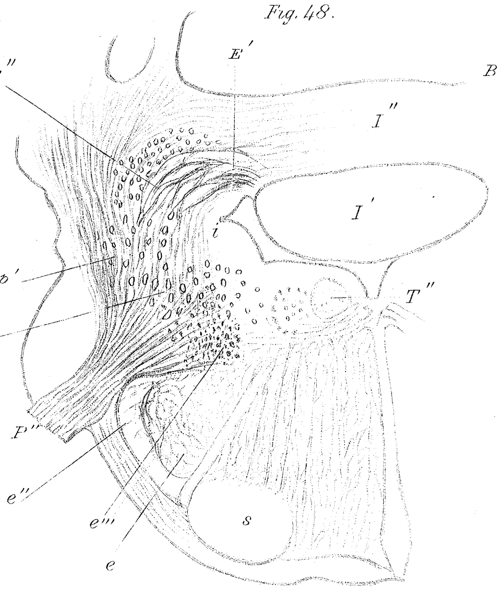

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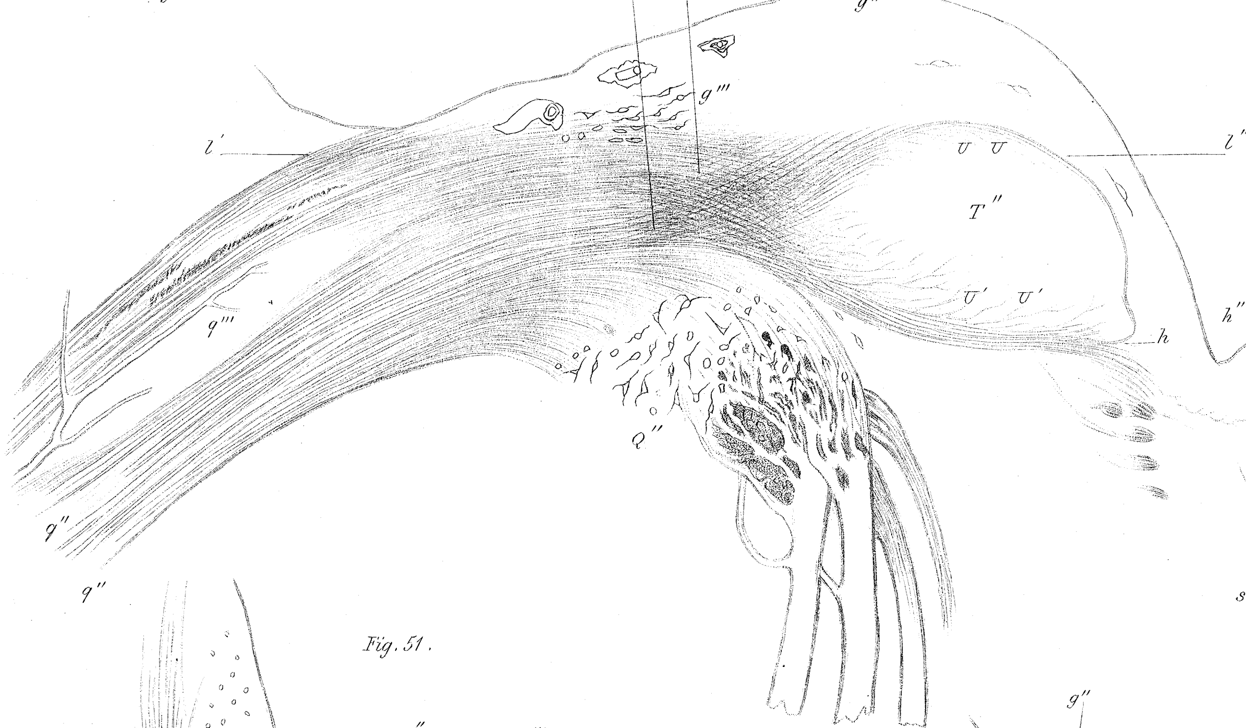
Fig. 56.



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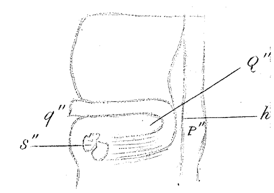

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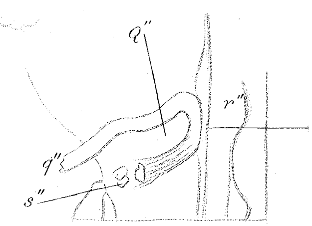

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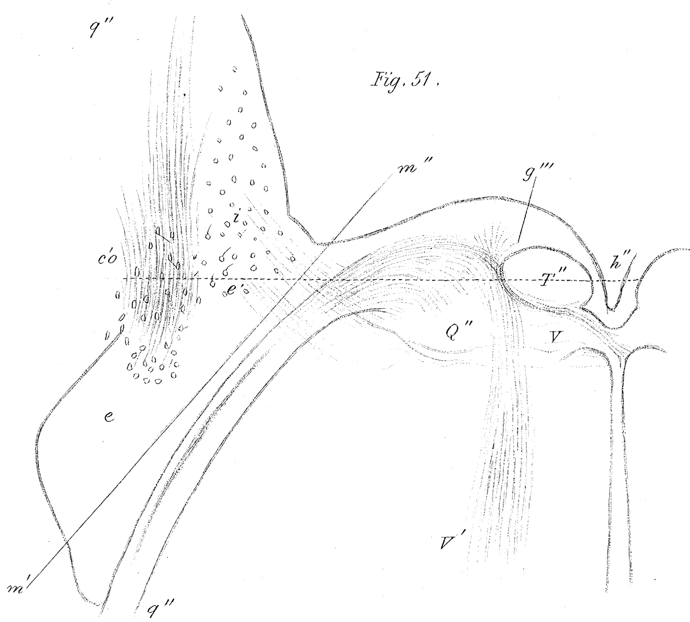

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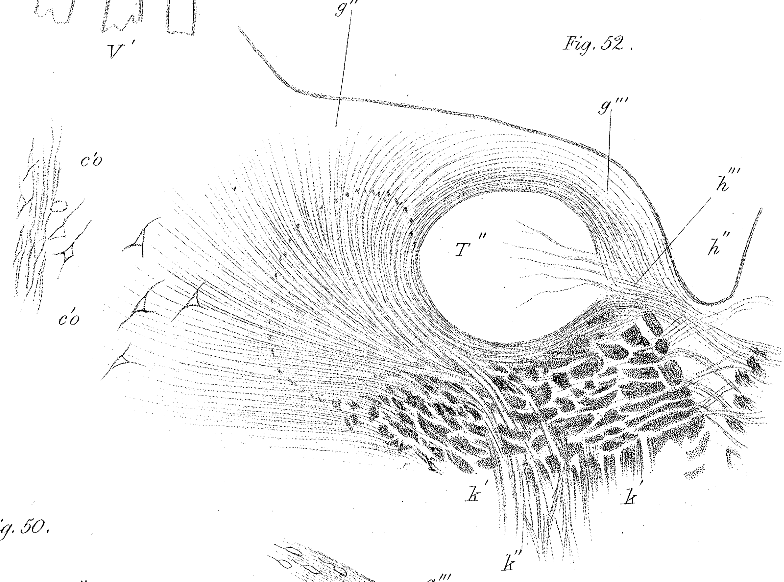

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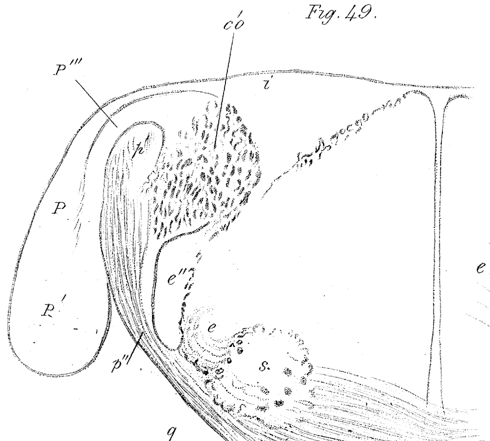

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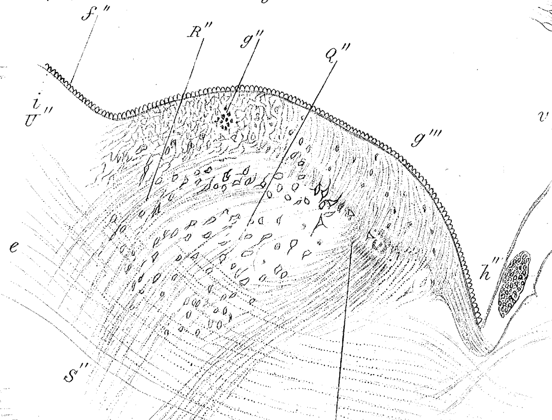

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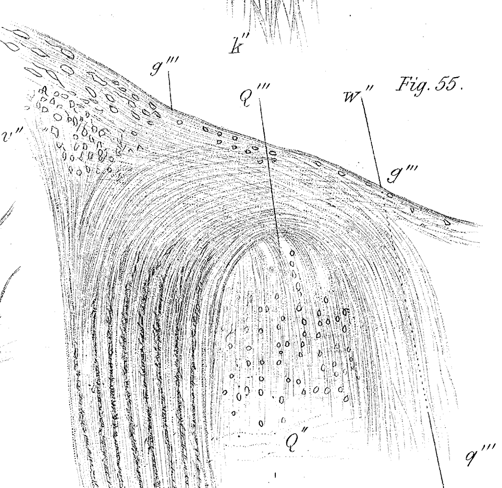

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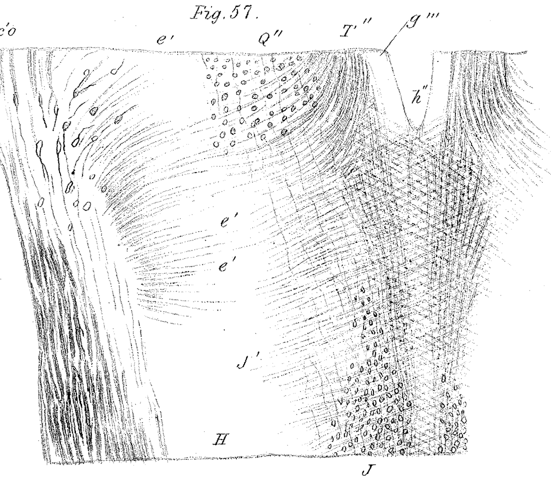

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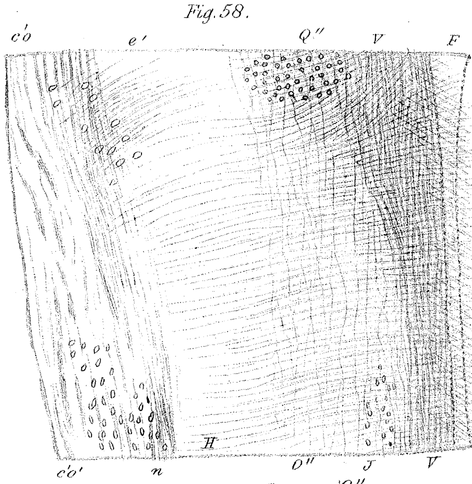

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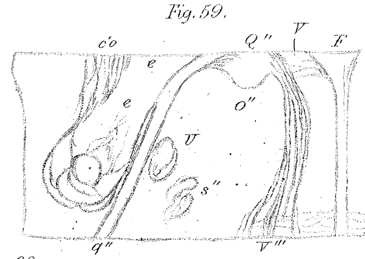

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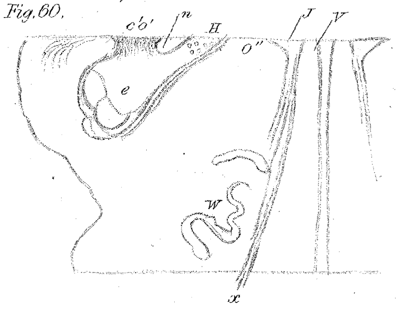
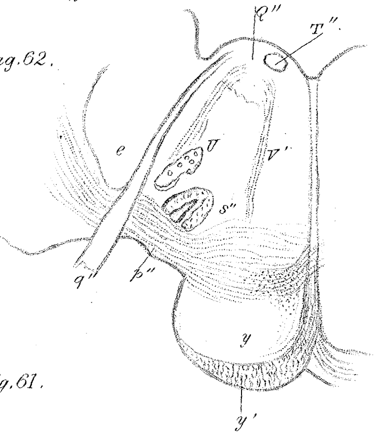


Fig. 64.

Fig. 62.



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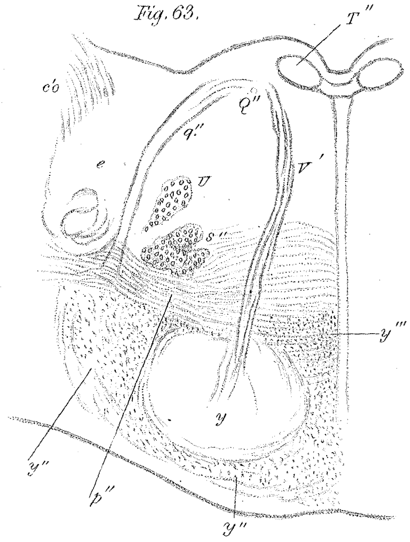

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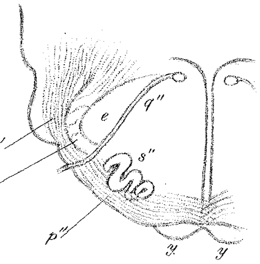

Fig. 64 A.
× 350.

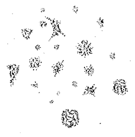

Fig. 64 B.
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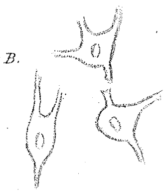
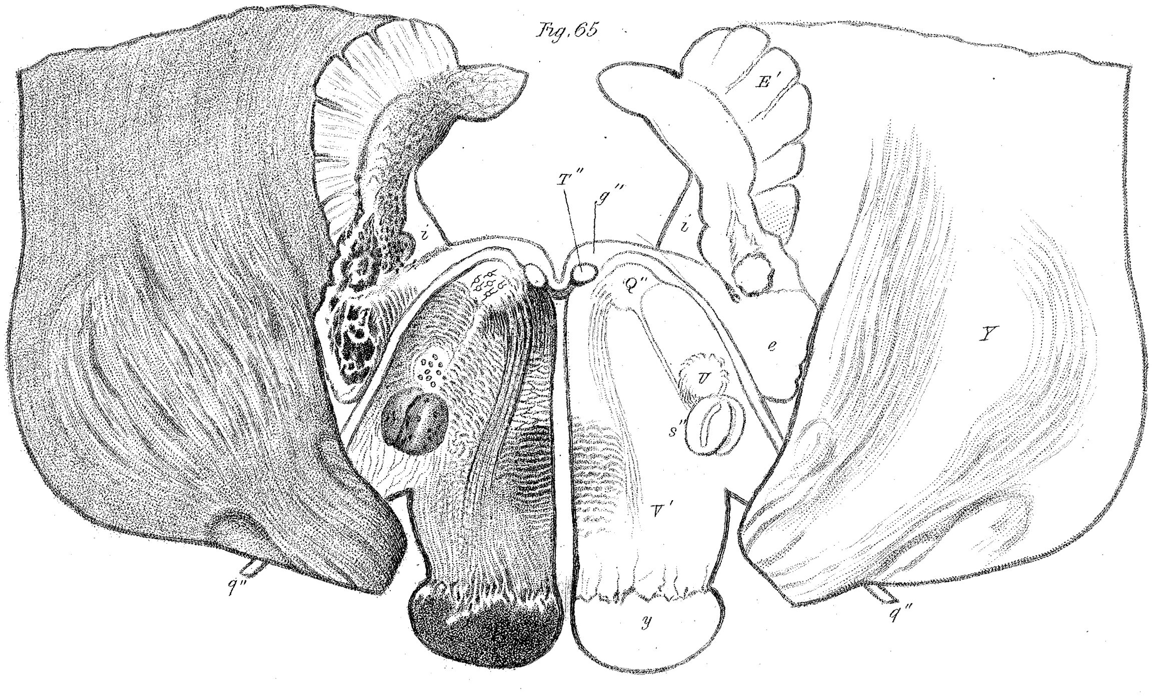


Fig. 65



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