Length of Different Portions of the Cord.—Ravenel (*loc. cit.*) gives the following measurements:

	In the male.	In the female.
Pars cervicalis	9.9 cm.	9.6 cm.
Pars thoracalis	26.2 "	22.9 "
Pars abdominalis	5.1 "	5.7 "
Pars pelvina	3.6 "	3.1 "

The thirty-one segments corresponding to the thirty-one pairs of nerve roots have been carefully measured in six individuals by Lüderitz (for the figures his original article is referred to). The longest segment is found about the middle of the pars thoracalis and corresponds to the fifth, sixth, seventh, or eighth N. thoracalis. The shortest segment usually pertains to one of the lowermost Nn. sacrales. The difference in length of segments is dependent upon growth relations. The length of the segments increases steadily from the lower part of the sacral cord up to the middle of the pars thoracalis, the increase being at first slight, between the individual segments, but higher up it is greater. The length of the segments then diminishes until the lowermost portion of the pars cervicalis is reached. In the latter the segments measure about alike, though there are slight variations.

Number of Spinal Nerves.—Thirty-one pairs of spinal nerves are usually described for human beings, though Rauber has demonstrated traces of a second and third coccygeal nerve lying close upon the filum terminale. Occasionally a sixth pair of sacral nerves is present when there are more sacral vertebræ than normal. Single thoracic nerves may be absent (Adamkiewicz).

Topographical Relations of Gray Matter and White Matter.—A most valuable contribution to our knowledge of the details of these relations is to be found in Bruce's "Atlas of the Human Spinal Cord." It includes photographs of transverse sections through every segment of the cord. It is of the greatest convenience in helping to localize the origin of transverse sections of the human cord of unknown level.

Exact measurements of the surface amounts of the white and gray substances at different levels of the cord have been made by Stilling, who even went so far as to measure the surface areas of the individual funiculi at nearly all levels of the cord. Stilling's book on the spinal cord is a mine of valuable statistics.

In Stilling's book (1859) there are data concerning the areas of white and gray substance in cross-sections of the spinal cord of a child of five years, and these data were later used by Woroschiloff (1874) for the construction of curves. His curves are those at present employed in most text-books, too often without any accompanying statement to show that they are based on the measurement from an immature cord. Another point to be borne in mind in dealing with curves representing the true relations between the gray and the white matter is this, that the segments of the cord should be represented in their true length. The curves worked out by Krause and Aguerre would have been more valuable had they paid attention to the lengths of the segments.

Donaldson and Davis, of the University of Chicago, have recently constructed curves in which not only the area of the entire section, but also those of the white matter and the gray matter separately are represented, and in which the age of the individual and the true lengths of the individual segments of the spinal cord have been regarded. The accompanying charts make clear at a glance the results obtained (Fig. 4385). Donaldson and Davis find that the form of the cord from one to five years is nearly like that of maturity, the difference being that in the mature cord the relative enlargement of the areas of the cross-sections has become greater in the thoracic region, but less in the sacral and coccygeal. At maturity the relative enlargement of the two intumescentiæ is practically the same as at the fifth year. From the fifth year to maturity both the length and the weight of the entire cord, as well as the area of the cross-sections at the level of the several segments, are increased. The sum of the areas of the white substance at maturity is ninety-eight per cent. greater than at five years, and that of the gray substance twenty-three per cent. greater. This absolute increase must represent either enlargement of elements

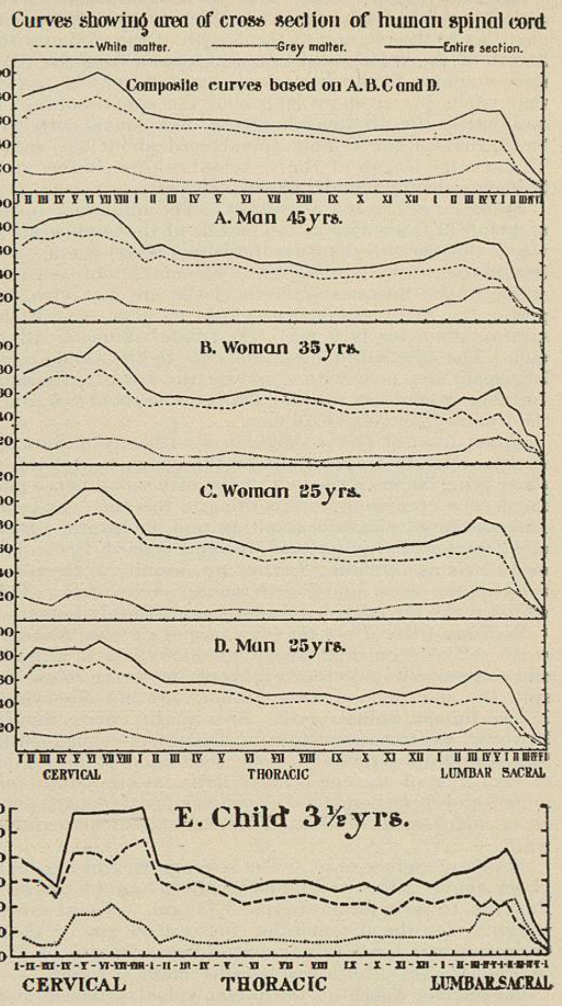

FIG. 4385.—This chart represents, by curves, the areas of the cross-sections of several human spinal cords, as well as the areas of the gray and white substances as they appear in each section. The base line in all the charts is just one-third the length of the spinal cord for which it stands, and is divided into lengths proportional to those of the spinal-cord segments of which it is composed. For the adult cord, the lengths of the segments given in the first table of the series were used in making the original drawings. On the ordinates one linear millimetre corresponds to one square millimetre of area. In all cases the measurement of the area was made up at the caudal end of the segment. In the order from above downward, the curves are as follows:

Composite Curve—Based on *A*, *B*, *C*, and *D*, to give the average of the several areas in the curves named. The curves are generalized and apply to a cord of medium length—441.6 cm. long. The influence of sex is neglected. The average age of the four cases would be thirty-three years. *Curve A*, Man of forty-five years; data for areas from Stilling. *Curve B*, Woman of thirty-five years; data for areas from Stilling. *Curve C*, Woman of twenty-five years; data for areas from Stilling. *Curve D*, Man of twenty-five years; data for areas from Stilling. *Curve E*, Child—data for areas from Stilling's observations on the cord of the two-year-old child. Length of segments from Lüderitz's observations on the cord of a three-and-a-half-year-old girl. Cord rather short. (After Donaldson and Davis.)

already completely developed or the development of elements still immature at the earlier age, or some combination of both of these processes. Yet the failure of the intumescentiæ to increase in their relative area in the mature cord or in their proportional length would seem

to indicate that during this period there was no increase in their relative complexity, a result which, to say the least, was unexpected.

Central Canal.—This is very often invisible in the adult. Its lumen may vanish for considerable distances. It is stated that the central canal may remain open in perhaps ten per cent. of the cases throughout its whole length. Headward it is continuous with the central canal of the medulla oblongata (fourth ventricle), while caudalward it can be followed as far as the middle of the filum terminale, where it ends blindly.

The form of the canal is usually circular or elliptical; in the latter case the longer diameter is most often sagittal. In the intumescentia cervicalis it is a transverse ellipse, and in the intumescentia lumbalis a dorso-ventral ellipse.

The gray matter about it has a gelatinous appearance (substantia gelatinosa centralis) and is rich in neuroglia and derivatives of ependymal cells.

The expansion of the central canal, known as the ventriculus terminalis, lies so near the posterior surface of the cord that some authors have assumed that it opens into the sulcus medianus posterior. No such communication, however, exists.

Heterotopias of the Gray Matter.—Most of the so-called heterotopias or displacements of the gray matter, like many of the so-called doublings of the gray matter and of the cord, have doubtless been due to artefacts produced by violence on removal of the cord. The subject has been thoroughly discussed by van Gieson, who gives credence to a true heterotopia in only a very few of the published cases.

Glial Sheath and Glial Septa.—The thin layer of glia just outside the substantia alba, much thicker in some parts of the periphery than in others, is known as the glial sheath (*Gliahülle* of the Germans). Running in from this glial sheath through the white matter to the gray matter can be seen various glial septa. An excellent description of the distribution of these glial septa is to be found in Ziehen's article on the "Nervous System," in Bardeleben's "Handbook," pp. 57–62.

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Microscopic Anatomy of the Spinal Cord.

We have now completed the description of the grosser anatomy of the cord, and shall next pass on to an account of the microscopic appearances. The anterior and posterior roots will first be described, then the white matter of the cord, and lastly, the gray matter. A description of the appearances as met with in ordinary sections will be given first, and afterward the special facts brought to light by special methods will be detailed. In what follows, the reader is expected to have some familiarity with the histology of nerve cells and nerve fibres, to know what is meant by a neurone, to understand the terms dendrites, axone, collaterals, telodendrion, perikaryon, etc. A brief account of all these features will be found in this Handbook under *Brain, Histology of,* Vol. II., pp. 331–344. A reader approaching the microscopic anatomy of the spinal cord for the first time would do well to read this section before going further.

The Anterior Roots.—The exit of the fila radicularia at the sulcus lateralis anterior has already been described. A cross-section of an anterior nerve root shows that it consists almost entirely of medullated nerve fibres, all of which represent axones of lower motor neurones, the cell bodies or perikaryons of which are situated in the columna anterior grisea or anterior horn, of the same side of the spinal cord. Generally speaking, the calibre of the nerve fibre of the anterior root exceeds that of the nerve fibre of the posterior roots. This is especially true of the anterior roots of the Nn. cervicales, Nn. lumbales, and upper Nn. sacrales, where fine fibres occur only singly in the anterior roots. On the other hand, in the anterior roots of the Nn. thoracales and lower Nn. sacrales there are numerous fibres of fine calibre often arranged in groups in among the larger fibres. The fibres of the anterior roots of the cervical nerves vary from 1.3 μ to 23.9 μ. Over half the fibres of these roots have a calibre of from 13.3 μ to 16 μ. The large fibres predominate in the lumbar region, where one-half of all the fibres measure from 21.3 to 23.9 μ (Siemerling). If fibres of more than 5 μ are called *coarse*, and fibres of smaller size are called *fine*, there are five times as many coarse as fine fibres in the anterior roots of the cervical nerves; three times as many fine as coarse in the anterior roots of the thoracic nerves; six times as many coarse as fine in the lumbar roots; four times as many coarse as fine in the sacral roots; and three times as many fine as coarse in the coccygeal nerve root. According to Schwabel the greater the length of a nerve, the larger the calibre of its root fibres, a conclusion which he drew largely from the predominance of the coarser fibres in the cervical and lumbo-sacral roots.

The total number of anterior root fibres in a woman twenty-six years old was found by Stilling to be 303,265. The older counts of Birge in the frog have been extended through the researches of Hardesty. For the details the original article of the latter may be consulted.

The fibres of the anterior roots are surrounded by a myelin sheath before they leave the cord, but only from the point where they leave the pia are they surrounded by a neurilemma and by the connective-tissue sheath, sometimes called the sheath of Henle.

Single nerve cells or small groups of ganglion cells have been observed occasionally outside the spinal cord among the fibres of the fila radicularia of an anterior root. His and Dohrn demonstrated that some neuroblasts could, in the embryo, pass through the marginal veil and get out into the anterior roots. Whether the nerve cells which have been observed in these roots in the adult are derivatives of neuroblasts from the anterior horns, or are dislocated spinal ganglion cells or sympathetic ganglion cells, has not yet been decided. Islands of glia cells have been seen among the anterior roots (Petrone) and the peculiar plaques observed by Hoche in anterior roots may be glial in nature. Ziehen suggests that they are to be looked upon as cone-like dislocations of the glial sheath of the spinal cord.

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The Posterior Roots.—In general the fibres of the posterior roots represent the central axones of the peripheral sensory neurones, the cell bodies or perikaryons of which are situated within the spinal ganglion. The fibres of the posterior roots are in general of finer calibre than those of the anterior roots, though the actual measurements vary between 1.3 and 23.9 μ; the same extremes are noted for the anterior roots (Siemerling). In the cervical posterior roots three-quarters of all the fibres have a calibre varying between 8 and 13.3 μ. In the thoracic posterior roots, two-thirds of all the fibres measure 13.3 μ or more. In the lumbar roots a fifth of all the fibres measure 21.3 μ, about one-quarter of them 18.6 μ, and still another quarter 16 μ. The proportion of fine fibres to coarse fibres in the cervical roots is as 21:20; in the thoracic roots as 7:5; in the lumbar roots as 8:9; in the sacral roots as 4:3; and in the coccygeal root as 17:14. The posterior root bundles are somewhat constricted at the point where they pass through the pia and enter the glial sheath of the cord. According to a much considered theory, proliferation of the connective tissue at this spot with increased constriction of the dorsal root fibres is the primary pathological change in tabes dorsalis (Obersteiner and Redlich).

According to Stilling, the number of all the posterior root fibres in a woman, twenty-six years old, was 504,473. Birge's counts concern the frog only. Lewin and Bühler have made counts, the former stating that in the rabbit the number of fibres peripheral from the ganglion is larger than that of the fibres entering the cord by 19 per cent. in the rabbit, and the latter maintaining an excess of 25.5 per cent. in the frog. Hardesty has shown for the frog that the number of fibres in the dorsal root decreases as the fibres pass from their cells of origin in the spinal ganglion. Dale made counts of the fibres on both sides of the spinal ganglion and found an average excess of only 0.5 per cent. on the distal side. The theories explaining the distal excess have been discussed by Hardesty, who made many counts, and whose article is referred to above.

A most important study of the medullated nerve fibres in the dorsal roots of the spinal nerves of man is that of Ingbert. In brief he has found:

1. The total area of the cross-sections of the dorsal roots of the left spinal nerves of a large man is 54.93 mm.
2. The total number of medullated nerve fibres in the dorsal roots of the left spinal nerves of the same man is 653,385; and the total number on both sides would therefore be about 1,306,770.
3. There are, on the average, 11,900 medullated nerve fibres to every square millimetre of the cross-sections of the dorsal roots of man.
4. There is a close relation between the area of the cross-sections of the dorsal roots and the number of nerve fibres which they contain (see Chart III.).
5. The small fascicles of a dorsal spinal root in general contain nerve fibres of small calibre.

6. The number of nerve fibres per square millimetre of the cross-section may vary considerably in the different fascicles of the same dorsal spinal root.
7. According to the estimate made, about sixty per cent. of the medullated nerve fibres in the dorsal roots of the spinal nerves of both sides, or 784,062 fibres, go to innervate the dermal surface, and about forty per cent., or 522,708, are sensory fibres distributed to muscles and deep tissues. The afferent fibres of spinal-ganglion origin, passing in the rami communicantes, are not separately considered in this estimate, but for the moment are classed with those passing to the deeper tissues.
8. According to Ingbert's estimate, one cutaneous nerve fibre in the dorsal spinal roots innervates on the average 1.7 $mm.^2$ of the dermal surface of the arm, 1.4 $mm.^2$ of that of the head and neck, 2.7 $mm.^2$ of that of the entire body, 3.2 $mm.^2$ of that of the leg, and 4.1 $mm.^2$ of that of the trunk; and for each additional class of nerve fibres assumed, we must increase the area proportionately.
9. If we assume with Foster four classes of cutaneous nerve fibres, then each fibre will have to innervate on the average 5.6 $mm.^2$ of the dermal surface of the head and neck and 16.4 $mm.^2$ of the dermal surface of the trunk.

Very interesting, too, are the discussions of Dunn on the number and on the relation between diameter and distribution of the nerve fibres innervating the leg of the frog. A description of these findings would exceed the limits of the space here provided, but references to the original articles are given below.

According to Lewin, there are in the rabbit many more spinal ganglion cells than there are fibres in the dorsal root. Thus for 3,200 dorsal root fibres, he found as many as 10,400 spinal ganglion cells. The neurilemma as well as Henle's sheath is arrested at the moment each posterior root fibre passes through the pia. The intramedullary continuations of the posterior root fibres are devoid of neurilemma, though they possess myelin sheaths.

Groups of ganglion cells in the dorsal roots at some distance from the spinal ganglion have been over and again demonstrated. Hyrtl spoke of them as *ganglia aberrantia*. Some of these may be true spinal ganglion cells; others may be sympathetic ganglion cells dislocated from the posterior horn of the gray matter of the cord.

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Anterior Funiculus.—The total number of fibres in the anterior funiculus in the frog has been counted by Gaule. In human beings a rather rough estimate has been made by Ziehen, whose numbers are as follows: Intumescentia cervicalis, 46,000; midthoracic region, 28,000; intumescentia lumbalis, 42,000. The same investigator has studied carefully the calibre of the nerve fibres in the anterior funiculus. He finds that fine and coarse fibres are mixed in the upper cervical region, the coarser fibres being toward the periphery and close to the fissura mediana anterior; the finer fibres being relatively more numerous near the gray matter (Figs. 4386 and 4387). The same is true of the cervical enlargement; in fact this mode of distribution holds more or less also through the whole of the pars thoracalis. In the intumescentia lumbalis and in the conus medullaris the distribution of fine and coarse fibres is more even, though on the whole the coarser fibres are somewhat diminished in numbers. It is rare to find fibres measuring more than 20 μ in diameter in the anterior funiculus in any part of the cord. Fibres of 9–12 μ are very numerous. Of the finer fibres some have a diameter no greater than 1.5 μ.

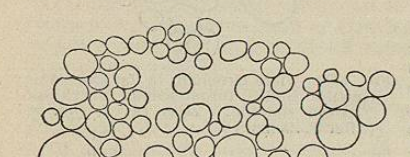

Fig. 4386.—Fibre Grouping in the Funiculus Anterior Near the Anterior Horn. (After T. Ziehen.)

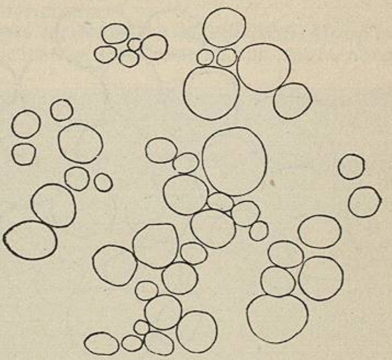

Fig. 4387.—Fibre Grouping in the Periphery of the Funiculus Anterior, Intumescentia Cervicalis. Nigrosin staining. Zeiss Oc. 2, Obj. F. (After T. Ziehen.)

The longitudinal fibres which make up the majority of the fibres of the funiculus anterior run for long distances. A careful study reveals fibres, especially in the medial posterior portion, turning partly posteromedialward to run in the commissura alba anterior, partly lateralward or posterolateralward, to turn into the columna grisea anterior or anterior horn. The fibres which go from the anterior horn to the anterior root are to be seen, running horizontally through the funiculus anterior. Very numerous collaterals are given off in a horizontal or a slightly inclined direction from the fibres of the funiculus anterior.

The distribution of the glia in the anterior funiculus has been described by Gierke, by Weigert, and by Ziehen. True nerve cells are seldom found among the fibres of the funiculus anterior except in the lowermost part of the conus medullaris. Even here they may be confused with large glia cells.

It is in the funiculus anterior that the so-called colossal fibres of lower vertebrates are found. In Teleosts two colossal fibres, often called Mauthner's fibres, are found between the so-called commissura accessoria of fishes (which run from the ventral horn transversely through the funiculus anterior accompanied by gray substance) and the central part of the gray substance. Each of these fibres may have a diameter measuring as much as 110 μ.

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Ziehen, T.: *Loc. cit.*

Lateral Funiculus.—There are counts of the nerve fibres available for the frog (Gaule) and for human beings (Ziehen). In man exclusive of Lissauer's fasciculus it is estimated that the numbers are about as follows: Intumescentia cervicalis, 275,000; midthoracic region, 240,000; intumescentia lumbalis, 260,000. If the region through which the anterior root fibres pass be added to the lateral funiculus, the numbers just given must be increased by 35,000, 24,000, and 37,000 respectively.

There are great differences in the calibre of the fibres in different parts of the lateral funiculus. Indeed a low-

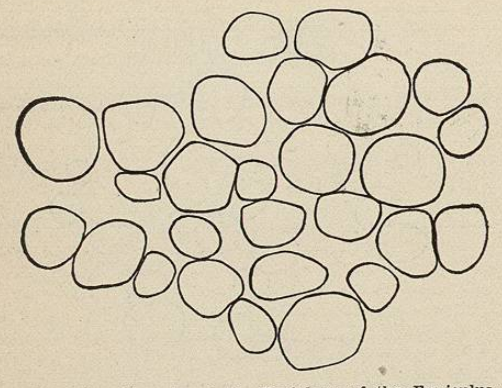

FIG. 4388.—Fibre Grouping in the Periphery of the Funiculus Lateralis. (After T. Ziehen.)

power study of the healthy lateral funiculus will permit one by means of the calibre of the fibres alone to delimit with some degree of accuracy the topographical distribution of the main fasciculi of which the lateral funiculus is made up. At the periphery the coarse fibres predominate, the dorsal portion of the periphery consisting almost exclusively of very coarse fibres (direct cerebellar tract). In the inner portions fine fibres predominate (pyramidal tract and ground bundle) (Figs. 4388 and 4389). The finest fibres in the lateral funiculus, at least in the pars cervicalis, are close to the gray substance (Flechsig's seitliche Grenzschicht der grauen Substanz).

While the majority of the fibres in the lateral funiculus run longitudinally, some fibres running transversely can

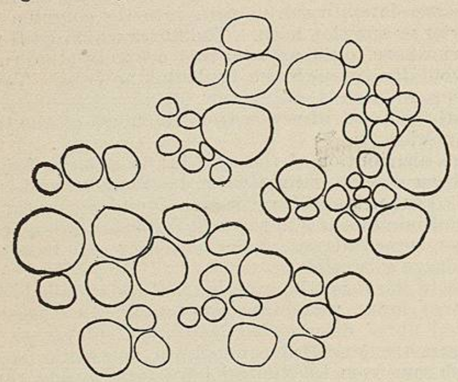

FIG. 4389.—Fibre Grouping in the Interior of the Area of the Lateral Pyramidal Tract; Intumescentia Cervicalis. Nigrosin staining. Zeiss Oc. 2, Obj. F. (After T. Ziehen.)

be seen. Among these may be mentioned the lateral fibres of the anterior root, fibres from the lateral margin of the anterior horn which pass lateralward or dorsolateralward and later assume a longitudinal direction, fibres from the lateral horn which pass dorsolateralward or lateralward, and especially fibres which pass from the neighborhood of the nucleus dorsalis for a short distance transversely and then obliquely upward and lateralward toward the direct cerebellar tract at the dorsolateral periphery. Bundles of fibres belonging to the root of the N. accessorius are to be seen in the upper and middle cervical region. They emerge from the gray matter in the region of the formatio reticularis.

Coming off from the fibres of the lateral funiculus, there can be seen, especially in vertical sections, large numbers of collaterals. They are particularly numerous as the gray substance is approached.

The glia distribution in the lateral funiculus presents no remarkable features.

A relatively large number of ganglion cells stand in close relation to the lateral funiculus. They are situated in the formatio reticularis and in the columna grisea lateralis.

In lower animals "colossal fibres" in various groups have been described in the lateral funiculus.

Posterior Funiculus.—Ziehen's counts of the nerve fibres yield for the posterior funiculus, exclusive of Lissauer's fasciculus, the following figures: Intumescentia cervicalis, 174,000; midthoracic region, 75,000; intumescentia lumbalis, 85,000.

The calibre of the nerve fibres in the posterior funiculus varies greatly and the distribution of the coarse and fine fibres is irregular. It is not easy to set up a sharp distinction between the distribution in Goll's fasciculus (Fig. 4390) and that in Burdach's. At the junction of Goll's and Burdach's fasciculi, the fibres are more closely crowded together than elsewhere. This is the so-called "band of condensation" of Sherrington.

The calibre of the fibres in Lissauer's fasciculus is very small, the average diameter probably not exceeding 2 or 3 μ. This seems to be due to the fact that when the fibres of the posterior root enter the white matter of the cord, the coarse fibres become separated from the fine, the former going into the so-called "entry zone" medial from the posterior horn, the latter accumulating in the interval between the substantia gelatinosa and the periphery of the cord to form Lissauer's fasciculus.

The main stems of the posterior root fibres may run for some distance forward and medialward before undergoing bifurcation into an ascending and a descending limb. In addition to these transverse fibres, one meets at all levels of the cord some longitudinal fibres, which are becoming transverse in order to run in and terminate in the gray matter, and more especially great groups of collaterals given off from different parts of the white matter to run horizontally or somewhat obliquely toward the gray substance. The collaterals of the posterior root fibres are confined chiefly, in the upper part of the cord, to Burdach's fasciculus. It is rare to find them given off from the fibres of Goll's fasciculus. The collaterals of the posterior funiculus are of the highest importance and will be described more fully farther on.

For a description of the glia of the posterior funiculus Weigert's book should be consulted.

It is rare to find dislocated ganglion cells among the fibres of the posterior funiculus, though Sherrington has occasionally met with isolated nerve cells, presumably derived from the nucleus dorsalis (Clarkii).

The "colossal fibres" so often found in the anterior lateral funiculus of lower vertebrates apparently do not occur in the posterior funiculus.

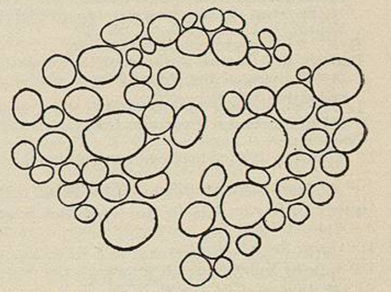

FIG. 4390.—Fibre Grouping in the Fasciculus Gracilis Golli; Intumescentia Cervicalis. Nigrosin staining. Zeiss Oc. 2, Obj. F. (After T. Ziehen.)

Each posterior root fibre bifurcates at an angle of from 120° to 160° into a short descending limb and a long ascending limb. The bifurcation takes place at a node of Ranvier. Some collaterals are given off from the root fibre before its bifurcation, but more from the limbs of bifurcation near their origin. It is these limbs of bifurcation which make up the majority of the fibres of the white matter of the posterior funiculus. Since these fibres have their origin in the cell bodies situated in the

spinal ganglia, that is, outside the spinal cord, they are often referred to as *exogenous* fibres. As we shall later see, the posterior funiculi contain in addition some *endogenous* fibres, that is, fibres which are processes of cell bodies that are situated within the gray matter of the cord.

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Ziehen, T.: *Loc. cit.*

Columna Grisea Anterior.—The form and size of the columna grisea anterior or anterior horn varies much, as seen in transverse section, at different levels of the cord. There is a type of form, however, which is characteristic of each segment, and for corresponding parts of segments in different cords, as will be easily seen by a study of the accurate photographic reproductions of sections through each of the segments of the human spinal cord pictured in Alexander Bruce's "Topographical Atlas." An examination of these figures shows that all the motor cells of the anterior horn in the cervical and lumbar regions and in the first thoracic segment may be divided into a *medial* and a *lateral* column of cells. I shall follow Bruce's description closely.

The *medial column* of cells is present throughout the whole length of the cord above the level of N. sacralis V., with the exception of the levels of N. lumbalis I., N. sacralis I., and the upper level of N. sacralis II. This medial column of cells in some sections forms a single group, but in others, especially in the pars thoracalis, is differentiable into an anterior medial column and a posterior medial column. The cells of the latter are smaller than those of the former.

The greatest development of the *anterior medial group* is met with in the levels of the N. cervicalis IV. et V., where besides the cells ordinarily present there is a large group of cells just lateral from them, possibly corresponding to the spinal centre for the N. phrenicus.

Below the level of the N. cervicalis V., the cells of the medial column gradually diminish in number in the cervical segment. In some sections only one or two cells, or even none at all, may be found. The number is again suddenly increased in the lower part of the eighth cervical segment, and this increase, according to Bruce, is maintained throughout the whole of the pars thoracalis.

It is well represented also in the four upper lumbar segments. In the first three lumbar segments Bruce described a few cells in a small anterolateral angle which may be included along with the medial group, or may be regarded as a special anterior group. The medial group of cells is absent in the fifth lumbar, first sacral, and upper part of the second sacral segments, but reappears in the lower part of this segment and is continued as far as the fourth sacral segment. It is absent again below this level.

The *lateral column* of cells is subdivisible in the cervical region into an *anterolateral* (ventrolateral) and a *posterolateral* (dorsolateral) cell column. In the lowermost part of the pars cervicalis an additional group, sometimes designated the *post-posterolateral*, exists. It is also to be found in the first thoracic segment, though the lateral cell column appears to be otherwise entirely unrepresented in the pars thoracalis. In the pars lumbalis, however, in the levels of origin of the Nn. lumbales and upper Nn. sacrales, both an anterolateral and a posterolateral column of cells are present. There is also to be made out, from the level of N. lumbalis II. to the upper part of the segment corresponding to N. sacralis II., a *central* group of nerve cells. Further, a post-posterolateral group of nerve cells (Onufrowicz) exists in the first, second, and third sacral segments. This is the group designated by van Gehuchten as the secondary posterolateral group.

In the pars cervicalis the anterolateral group is really subdivisible into two sections: an *upper anterolateral* section, which extends from the upper limits of the fourth to the upper part of the second segment, attaining its maximum development in the fifth segment; and a *lower anterolateral* group, which extends from the upper third of the sixth to the middle of the eighth segment (Fig. 4391), attaining its maximum development at the seventh segment. The two anterolateral groups thus coexist in the sixth segment (Bruce).

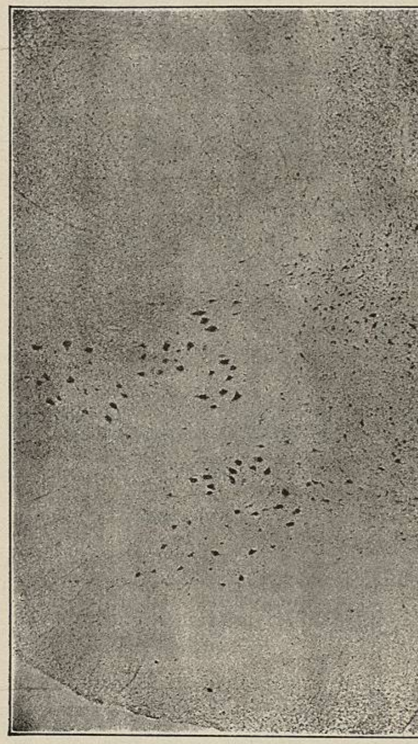

FIG. 4391.—Toluidin Blue Preparation of the Upper Part of the Eighth Cervical Segment of the Human Spinal Cord. (After A. Bruce, "A Topographical Atlas of the Spinal Cord," Edinburgh, 1901.) The anterior mesial group consists of four cells. The posterior mesial is not represented. The antero-lateral and postero-lateral groups are more sharply differentiated than in any other segment. The (lower) anterolateral group contains twenty-nine cells. Eleven of these are concentrated into an apparently distinct group at the posterior part of the main group, and consist of larger and more deeply stained cells. The posterolateral group consists of thirty cells, and shows a tendency to division into an inner group consisting of sixteen cells, and an outer group consisting of fourteen cells. Behind there is a post-posterolateral group of three cells.

In the fifth and eighth segments there is an indication of subdivision of the anterolateral group into three subordinate nuclei, one anterior, one medial, and one posterior.

The posterolateral cell column is not present above the fourth cervical segment. Below this level, the cells increase in number rapidly, reaching their maximum at the fifth and sixth segments, where they form the prominent posterolateral angle. This posterolateral cell column is not well marked in the seventh segment, but is increased in size again in the eighth cervical segment, coincident with the marked increase in size of the posterolateral angle in this segment.