ably in appearance from that of the axone, especially in fixed preparations. In entirely fresh specimens taken from an animal just killed, little if any difference can be made out, the protoplasm in all parts of the neurone being homogeneous. The protoplasm of the cell body contains an attraction sphere or archiplasm within which are situated one or more centrosomes. The peripheral portion of the protoplasm or so-called exoplasm differs somewhat in appearance from the central portion of the protoplasm or so-called endoplasm, the former showing a more marked tendency to a fibrillar structure, the latter showing in most preparations a somewhat more granular appearance. The ground substance of both exoplasm and endoplasm looks in ordinary preparations to be more or less homogeneous.

The nucleus of the nerve cell or neurone is always situated in the cell body, never in one of the branches, and as a rule occupies nearly a central position under normal conditions. This nucleus is larger than that of most cells of the body, is very poor in substances which stain in nuclear dyes, the so-called achromatic portion of the nucleus being relatively very abundant. There is nearly always one large, easily stainable nucleolus. Sometimes the nucleoli are multiple.

The appearance of the protoplasm of the neurones varies with different methods of preparation. With certain methods the protoplasm has a spotted appearance owing to the staining of bodies known as *tigroid masses*, or *Nissl bodies* (Fig. 919). By other methods a vacuolar or spongy network can be demonstrated, and in the meshes of the network certain minute staining bodies, the so-called *neurosomes*, appear. By still other methods of preparation a fibrillar structure becomes apparent. Accordingly, very divergent views prevail as to the ultimate nature of the protoplasmic structure, each investigator's

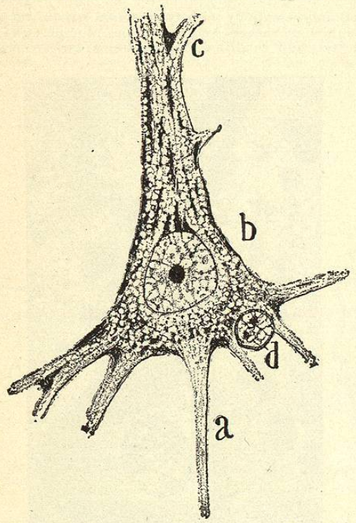

FIG. 919.—Part of a Pyramidal Cell from the Cerebral Cortex Showing the Tigroid Masses. (After Ramón y Cajal, S., "Textura del sistema nervioso," Madrid, 1899, p. 121, Fig. 37.)

views being colored by the method with which he is most familiar and in the results of which he places most confidence. Until further knowledge has been gained it is safer for the neuro-histologist to work with the various methods, describing accurately the results attained with each, and holding his mind open with regard to the ultimate nature of the substance he is working with.

In sections stained with Nissl's and similar methods the protoplasm of the neurone is seen to be made up, aside from any pigment which may be present, of two main constituents: one which stains in the basic dye employed, and another which remains unstained in this dye. The former substance is known as the *stainable substance* of Nissl, the latter as the *unstainable substance* of Nissl. The terms chromatic and achromatic have been applied to these two substances, but there are objections to their use.

The stainable substance of Nissl usually occurs in masses of varying size and form. Again, the masses themselves may be arranged in rows, groups, or networks so as to give a characteristic appearance to the cell. Each of the masses in turn may possess a definite structure, but this varies greatly with the mode of fixation which has been employed. Thus a single mass may with one kind of fixation be made up of very minute granules, with another kind of fixation of very much coarser granules. Vacuole-like appearances in the individual stainable masses are also frequently met with. These stainable bodies in the nerve-cell protoplasm (first seen and described by Flemming) have been subsequently studied by a large number of investigators, and notably by Nissl, who has made the appearance caused by their presence in different nerve cells the basis of an elaborate classification. They are frequently spoken of in neurological articles as Nissl bodies, but it is better to employ the term introduced by von Lenhossék, namely, tigroid bodies or tigroid masses, from the Greek word τίγροειδής, spotted.

The larger tigroid masses tend to assume definite forms with a given method of fixation, and these forms appear to be constant in the same variety of nerve cell from different individuals. Three of the more interesting forms of tigroid bodies are the nuclear caps, the wedges of division, and the tigroid spindles.

Nuclear caps are masses of tigroid, shaped more or less like cones, each cone being hollowed out inside. These cones of tigroid sit usually upon the nucleus of the nerve cell. As a rule, when they are present in the neurone there are two nuclear caps corresponding to two opposite nuclear poles.

The *wedges of division* are masses of stainable substance situated at the point where a dendrite divides into two branches. The base of the wedge is directed away from the body of the nerve cell.

The *tigroid spindles* consist of oblong or spindle-shaped masses of the stainable substance. These spindles, thick in the middle, become thin at the extremities and sometimes run out into long, thread-like forms.

The stainable substance of Nissl is limited to the perikaryon and to the dendrites. It is not found in the axone nor in that portion of the cell body from which the axone is immediately derived. This area of the cell body free from the stainable substance of Nissl is known as the axone hillock.

On the basis of findings in specimens stained by his method Nissl divides all nerve cells into two great groups. In the first group, that of the *somatochrome* nerve cells, he includes the cells in which the cytoplasm surrounds the nucleus completely and exhibits a distinct contour. This group includes: (1) the *arkyochrome* nerve cells; (2) the *stichochrome* nerve cells; (3) the *arkyostichochrome* nerve cells, and (4) the *gryochrome* nerve cells.

By *arkyochrome* nerve cells (Fig. 920) Nissl refers to those in which the stainable substance of the protoplasm is arranged more or less in the form of a network.

The term *stichochrome* is applied to the nerve cells in which the masses of tigroid are arranged in rows or threads which run in a similar direction. The best example of a stichochrome nerve cell is met with in the nerve cells of the nuclei of origin of the spinal and cerebral motor nerves.

By *arkyostichochrome* nerve cell Nissl formerly meant

a type of cell in which there was a combination of the arkyochrome arrangement with the stichochrome arrangement. He cited, as an example of this type, the Purkinje cells of the cerebellar cortex. Since making his original classification Nissl has suggested certain alterations,

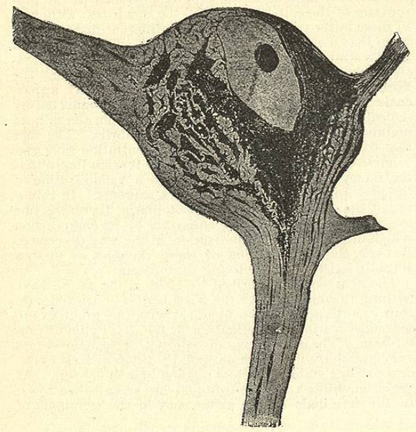

FIG. 920.—Nerve Cell from Olfactory Bulb of Rabbit. (After Nissl.) Somatochrome nerve cell of the arkyochrome variety in the parapyknomorphous condition.

among which is one in which he gives up the term arkyostichochrome, classing cells of that group now among the arkyochrome cells.

Nerve cells in which the stainable substance is present in the form of minute granules without any very definite arrangement are called *gryochrome* nerve cells by Nissl.

The second great group of nerve cells in Nissl's classification includes all cells not falling in the former group. And Nissl divides the cells of this group into (1) *cytochrome* nerve cells and (2) *karyochrome* nerve cells.

In the *cytochrome* nerve cells only traces of a cell body are to be made out. The nucleus is about the size of that of an ordinary leucocyte. Several varieties of cytochrome cells are distinguished by Nissl.

The *karyochrome* nerve cells also possess only traces of a cell body; but the nucleus is larger than that of the cytochrome nerve cell, being always larger than the nuclei of the neuroglia cells and as a rule of the size of ordinary nerve-cell nuclei.

A further subdivision of the cells of each of the categories above mentioned is based upon the differences in staining which the individual cells show. Thus, cells which are stained extremely deeply are designated by Nissl as *pyknomorphous* cells—that is, cells in which the tigroid masses are very closely arranged in the cell body. On the other hand, cells in which the stainable substance is present in small amounts are designated as *apyknomorphous* cells, the tigroid masses being rather widely separated from one another by the non-stainable substance. The term *parapyknomorphous* has been introduced by Nissl for stages intermediate between the pyknomorphous and the apyknomorphous condition.

Care must be taken in working with Nissl's method not to lay too much stress upon certain appearances in the nerve cells. Now and then in ordinary preparations a single cell or a group of cells will be found to be stained most intensely, as though the stainable substance of Nissl were uniformly distributed through the cell and were present in large quantities. These cells are called by Nissl *chromophile* nerve cells. They are in all probability artefacts due to the mode of fixation of the tissue in which they occur.

In sections of nerve cells stained by Held's method, especially if the sections be cut very thin (0.5 to 1 μ), the tigroid bodies are found to present a finely granular appearance. Each tigroid mass or Nissl body, if studied with an oil-immersion lens, is seen to be made up of a mass of granules often varying in size and sometimes exhibiting a characteristic arrangement. Along with the granules another substance, which Held describes as a coagulum-like mass which stains somewhat differently by his method from the principal granules of the tigroid mass, can be made out. Vacuoles of different sizes occur also in the tigroid bodies. Held is of the opinion that the tigroid bodies do not occur preformed in the nerve cell inasmuch as no indication of their presence can be made out in perfectly fresh nerve cells when examined with the very best optical apparatus. He believes, and I agree with him, that the substances which form the tigroid are precipitated substances. By the use of fixing reagents of different kinds, or even by the use of alcohols of different strength, the constituent granules of a tigroid mass may be precipitated in different ways. Whereas forty-per-cent. alcohol throws down these substances in very fine granules, ninety-six-per-cent. alcohol will precipitate them in much larger granules. The significance of such an observation for pathological histology is obvious, for if one is to draw conclusions with regard to changes in the tigroid masses in disease he should make sure that the pathological tissues he studies shall be compared with normal tissues from exactly the same region, fixed and prepared in precisely the same way.

FIG. 921.—Nerve Cell from Deiters' Nucleus in the Rabbit. Section 3 μ thick. The tissue has been exposed to the digestive action of a mixture of pepsin and hydrochloric acid at 40° C. for twelve hours. The ground substance has been dissolved out and the Nissl bodies alone remain. (After Held.)

The tigroid masses are not digestible in artificial stomach juice; whereas the unstainable substance of Nissl quickly digests in this fluid (Fig. 921). On the contrary, weak and strong solutions of the alkalies will dissolve out the tigroid masses, but will leave the unstainable

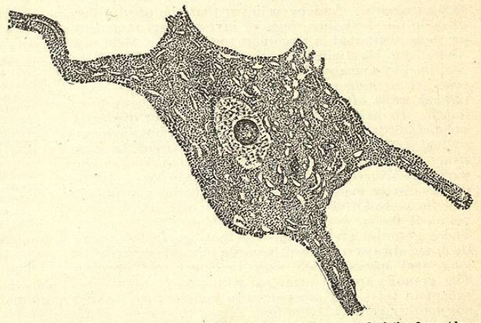

FIG. 922.—Nerve Cell from the Gray Matter of the Lumbar Cord of the Ox. Alcohol fixation. Treatment for four days in concentrated aqueous solution of lithium carbonate. The Nissl bodies have been dissolved out, and the ground substance alone remains. (After Held.)

substance of Nissl practically unaltered (Fig. 922). The chemistry of the tigroid bodies is interesting. The substances of which they are made up has been shown to contain iron and phosphorus. It seems not unlikely that these substances should be grouped among the nucleo-albumins or nucleo-proteids.

As to the unstainable substance of Nissl, very little can be made out if the method of Nissl alone be employed. Stained by his method and mounted in benzin colophonium his unstainable substance shows no structure, or if any but little, and so in such preparations is often described as the colorless, homogeneous ground substance of the nerve cell. Other methods of preparation, however, reveal in this unstainable substance of Nissl very remarkable appearances. Among the methods most suitable for its examination may be mentioned Held's modification of Nissl's method. Very careful studies by this method have been made by Held himself. The ground substance of the nerve-cell protoplasm which corresponds to the unstainable substance of Nissl is stained of a deep red color by this method; while the tigroid bodies or stainable substance of Nissl are stained of a blue color. It is easy to estimate the relative quantities of the two substances present and to make out their reciprocal relations in cells of different types. Thus, for example, the tigroid in the cell bodies of the nuclei of origin of the motor cerebral nerves and the cell bodies of great reflex systems (such, for example, as those of Deiters' nucleus) is found to preponderate, the ground substance in such cells being limited to what looked like narrow beams and bridges between the tigroid masses. On the other hand, the tigroid is relatively scanty in the large cells of Betz in the cerebral cortex, in the huge flask-shaped cells of Purkinje in the cerebellar cortex, and in numerous other cells in the brain. In these cells the amount of ground substance is relatively much greater than that of the tigroid. If the dendrites be followed out into their finer subdivisions one comes always sooner or later to a part of the dendrite where tigroid bodies disappear.

The ultimate branchings of the dendrites, as far as can be made out by Held's method, are devoid of the tigroid substance. These ultimate branches of the dendrites, together with the axones and the axone hillock which are also entirely free from tigroid, form the most suitable places for the study of the ground substance by itself. Held finds in this ground substance longitudinal threads and cross threads which he takes to be sections of honeycomb network, the spaces of which are stretched out lengthwise and arranged in rows; that is to say, Held sees in the ground substance of protoplasm a structure like that postulated by Bütschli for protoplasm in general. He lays emphasis on the fact that very different pictures are obtainable by the use of a variety of fixing reagents. And he believes that the great differences in the deviating views of investigators in general are to be attributed in large part to this fact. Held concludes from his studies that the fibrils which have been described by so many observers in the axis-cylinder processes are nothing more than the sections of the longitudinal walls of the honeycomb structure above mentioned. He has never been able to make out distinctly isolated fibrils running near one another, but in longitudinal sections of the axone or cross sections of the same structure he makes out constantly a network or meshwork-like structure. The meshes vary in size. In the meshes can be made out granules, sometimes very fine, sometimes somewhat larger, lying most often in the nodal points of the network, or also frequently in its spaces. These granules are arranged so that two or several of them are always contained between one or several of the long oval spaces which vary in length and breadth. The granules are not arranged with perfect regularity, except in this: they are placed in definite rows behind one another parallel to the long axis of the axone. This arrangement in rows is explained from the position of the granules as regards the long-meshed network of the axone. Held designates that part of the protoplasm of the axone which gives the appearance of a meshed structure as the *axospongium*, while the granules just referred to he calls *neurosomes*. While these neurosomes are most easily demonstrable in the axone and axone hillock, they are by no means confined to these structures but are also present in the ground substance of the protoplasm of the cell body and of the dendrites; although in these latter regions they have a different arrangement from that met with in the axone. It will be seen that Held's studies are closely in accord with the investigations of Bütschli, who has always maintained that the fibrils described by other investigators are only apparently fibrils, and that they are everywhere connected by delicate transverse threads which arise from the minute nodular swellings seen on the so-called fibrils. The fact that fixing reagents of different concentration give rise to meshworks of different size makes it seem likely that the honeycomb appearance is due to a vacuolization of the protoplasm caused by the fixing reagents. In thinking of the actual structure of protoplasm, therefore, one must conceive of certain peculiarities of its composition which determine its vacuolization in the way described. But one should not think of these vacuoles or meshes actually existing in the living protoplasm.

The neurosomes described by Held in the axone have nothing in common with the Nissl bodies or tigroid substance, but appear to be identical with the granules observed by various investigators in the axis-cylinder protoplasm. The number and distribution of the neurosomes vary markedly in the same and in different axis cylinders. They stain by Held's method of a violet tint. At the axone hillock the neurosomes are arranged in rows. In the terminals of the axone and in the terminals of

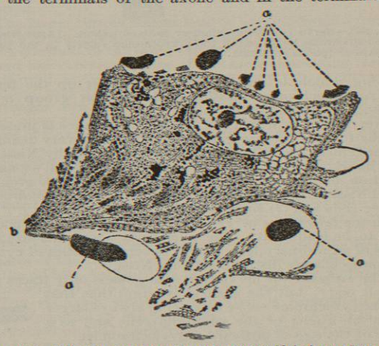

FIG. 923.—Cell of the Nucleus Corporis Trapezoidei of an Adult Rabbit. Fixation with Van Gehuchten's mixture; paraffin section 1.5 μ thick; erythrosin methylene-blue staining. (After H. Held, *Arch. f. Anat. u. Physiol.*, Anat. Abth., Leipsic, 1897, Taf. x., Fig. 3.) The axis cylinders (*a*) which go by the cell are stained homogeneously; the fibres (*b*) terminating in the cell contain large numbers of isolated neurosomes; the lower border of the cell enclosed by the terminal axone shows very distinctly a most intimate union between the axis-cylinder protoplasm and the ground substance of the cell body, since here the same plasma layer is common to both. On the right-hand side the cytospongium is wide-meshed, owing to coarse vacuolization, on account of which the axis-cylinder terminal looks to be more independent from the rest of the cell mass.

collateral branches of the axone the neurosomes are extremely abundant—much more abundant than in any other part of the nerve-cell protoplasm (Fig. 923).

The protoplasm of an axis-cylinder process of a neurone is continuous through the axone hillock with the ground substance (unstainable substance of Nissl) of the cell body and dendrites. But in the cell body and dendrites the anatomical appearances are complicated by the presence of the tigroid bodies which are deposited in them in various forms. Held's method shows

a very similar structure in the cell body and dendrites to that met with in the axone, as far as the ground substance is concerned. The meshwork in the cell body resembles the axospongium of the axone, but the meshes are somewhat less close and the staining shows some differences. The arrangement of the meshwork is of course also influenced by the deposition of the tigroid masses. Held calls the meshwork in the cell body the cytospongium. The neurosomes in the cell body vary in size, number, and distribution in different nerve cells. In the dendrites neurosomes can be seen in rows placed in such close apposition that they look like beaded rods.

The neurosomes are well seen in specimens fixed in neutral chromate solutions which do not precipitate the tigroid bodies. When sections of such tissues are stained with iron hæmatoxylin the form, number, and distribution of the neurosomes are particularly clear.

Other views of the ultimate structure of the ground substance are held by Flemming, Altmann, Ramón y Cajal, and Dogiel.

Flemming maintains the existence of definite fibrils in the ground substance. He does not, however, deny the possibility that these fibres may form the network.

Altmann, who has directed his attention chiefly to the granules in nerve cells observable by his particular method of staining, speaks of granules and of an intergranular substance. At least a part of Altmann's granules corresponds to the neurosomes of Held; while a large part of Altmann's intergranular substance evidently corresponds to Held's cytospongium and axospongium.

Ramón y Cajal describes the ground substance as consisting of a network with granules situated at the nodal points.

Dogiel, who is an adherent of the fibrillar doctrine, describes very fine fibrils in the ground substance. He finds that the fibrils have a definite and peculiar arrangement, differing in different types of nerve cells. He describes and pictures minute granules in his fibrils. As far as one can tell from a comparison of his illustrations with those of Held, it must be concluded that the granules in Dogiel's fibrils are identical with the rows of neurosomes described and pictured by Held.

Very different appearances from those just described are met with in the protoplasm of the nerve cells if they be stained by the hæmatein or the gold-chloride method of Apáthy. These methods demonstrate morphological constituents inside the protoplasm which appear to be definite fibrils. In many places the fibrils are independent of one another, but especially in the cell body they anastomose freely, according to Apáthy, to form a neural reticulum.

Apáthy, whose work has been chiefly upon invertebrate animals, divides all cellular elements within the nervous system into two kinds of cells, which he designates "nerve cells" and "ganglion cells" respectively. The "nerve cell" has the power of building neurofibrils

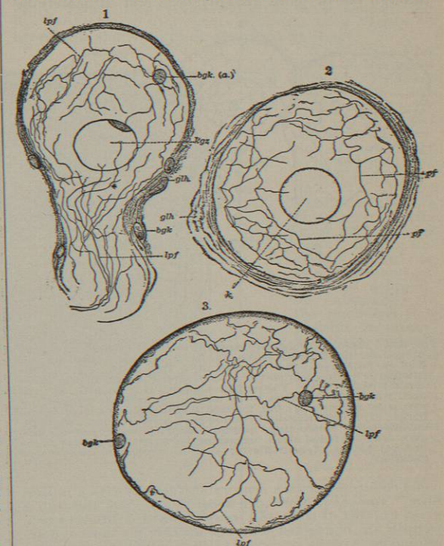

FIG. 925.—Colossal Ganglion Cell (Type *G*) from the Leech. (After S. Apáthy, "Mitth. aus der Zool. St. zu Neapel," Bd. xii., 1897, H. 4, Taf. xxviii., Figs. 4, 5, and 6.)
(1) The neurofibrils of a colossal ganglion cell of a posterior median section, with indication of the external glia sheath and connective-tissue nuclei. *bgk*, Connective-tissue nucleus; *glh*, glia sheath; *kgz*, nucleus of the ganglion cell; *lpf*, "conducting" primitive fibril.
(2) Cross section of a ganglion cell of type *G*, showing plexus of neurofibrils.
(3) Section of a colossal ganglion cell with plexus of neurofibrils. The meridian-like decussation of the neurofibrils at the pole of the cell is illustrated.

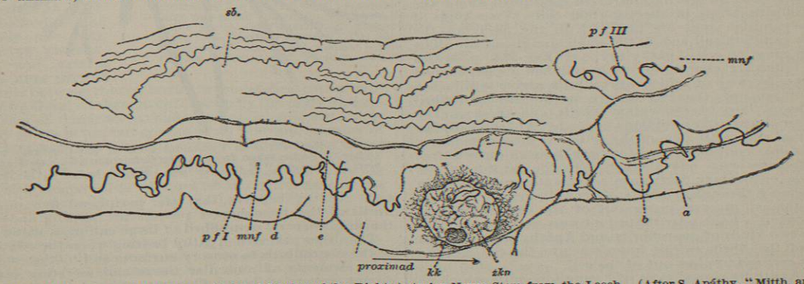

FIG. 924.—Motor-Nerve Spindle in Longitudinal Section of the Right Anterior Nerve Stem from the Leech. (After S. Apáthy, "Mitth. aus der Zool. St. zu Neapel," Bd. xii., 1897, H. 4, Taf. xxiv., Fig. 3.) The somatoplasm of the nerve cell is simply indicated around the cell nucleus, *zkn*. Near this nerve spindle are seen some primitive fibrils in sensory bundles, *sb.*; the contours of the motor-nerve spindle correspond to a focus somewhat above the level of the nucleoli; those branches of the motor nerve-divide, *mnf*, which are visible, are *a*, *b*, *c*, *d*, *e*. *pf I* represents the primitive fibril projected upon the surface of the drawing paper as far as it is contained in the section. The dotted points correspond to the place where it is not contained in the section. The asterisk indicates a division of the primitive fibril into two limbs.

(Fig. 924), while the "ganglion cell" does not possess this power. Neurofibrils built by "nerve cells" can, however, leave the cell in which they arise and pass through one or more ganglion cells and ultimately be-

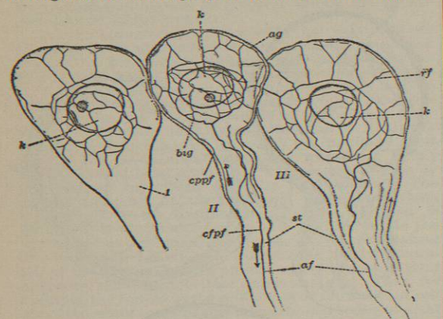

FIG. 926.—Three Pear-Shaped Ganglion Cells of Type *K*, in Longitudinal Section from the Leech. (After S. Apáthy, "Mitth. aus der Zool. St. zu Neapel," Bd. xii., 1897, H. 4, Taf. xxviii., Fig. 7.) The internal or perinuclear plexus of neurofibrils is well shown, as are also the radial fibres. The peripheral plexus is indicated. *af*, Axis fibril which Apáthy takes to be motor; *ag*, external intracellular plexus of neurofibrils; *big*, internal perinuclear plexus of neurofibrils; *cfpf*, cellulifugally "conducting" primitive fibril, see *cppf*, cellulipetally "conducting" primitive fibril; *k*, nucleus of the ganglion cell; *rf*, radial fibrils connecting the external plexus with the internal plexus of neurofibrils; *st*, stem process of pear-shaped ganglion.

come connected with a sensory surface or with a muscle fibre. One neurofibril can accordingly pass through a great number of cells, and inasmuch as the different neurofibrils are connected with one another by means of anastomoses, Apáthy conceives of the conducting apparatus in the whole nervous system as a continuum of neurofibrils. A neurofibril varies in calibre in different parts of its course, being largest where it arises. It consists, according to Apáthy, of a complex of "elementary fibrils," and as the neurofibril follows its course through a series of "ganglion cells" it gives off on its way at shorter or longer intervals numerous elementary fibrillæ until finally it itself consists of one elementary fibril. While the neurofibrils pass through ganglion cells which do not give origin to them, Apáthy has put forward the hypothesis that the force which is to be conducted along the neurofibrils arises in the ganglion cell. Two kinds of these ganglion cells are met with in the leech: (*a*) the large ganglion cell and (*b*) the small ganglion cell. The large ganglion cell, Apáthy's type G (Fig. 925), possesses the following characters: each cell has a pear-shaped process by way of which neurofibrils arrive within the protoplasm of the cell. Once inside, the neurofibril breaks up into its elementary fibrils, and these can be seen to diverge like meridians into what Apáthy calls the external chromatic zone of the cell. As these elementary fibrils pass peripheralward they can be seen to form free anastomoses with one another. On the far side of the cell the elementary fibrils turn round and converge again by passing through the body of the cell once more at the pear-shaped process, going out of the cell as another neurofibril. Each pear-shaped process accordingly contains two kinds of neurofibrils, and Apáthy suggests that one of the fibrils carries impulses into the cell and the other carries impulses out of the cell.

In Apáthy's second type of "ganglion cell," which he calls the "small ganglion cell" and designates as "type K" (Fig. 926), somewhat different appearances are met with. Each pyriform process contains within it one thick neurofibril, which passes nearly through the centre of the process, and several finer neurofibrils in the periphery of the process. The finer neurofibrils, however, entering the cell body pass out to the periphery of the protoplasm of the cell and break up into a dense reticulum formed by the anastomosis of the "elementary fibrils" of which they are composed. This anastomosis occurs in what Apáthy calls the outer chromatic zone of the cell. Small rami of the fibrils pass from this peripheral plexus inward to reach the internal chromatic zone of the cell, where another rather fine plexus of elementary fibrils is formed. The composing fibrils of this plexus, after having undergone free anastomosis, converge and pass toward the pyriform process, where they unite to give rise to the single large neurofibril, which passes away from the cell through the centre of the pear-shaped proc-

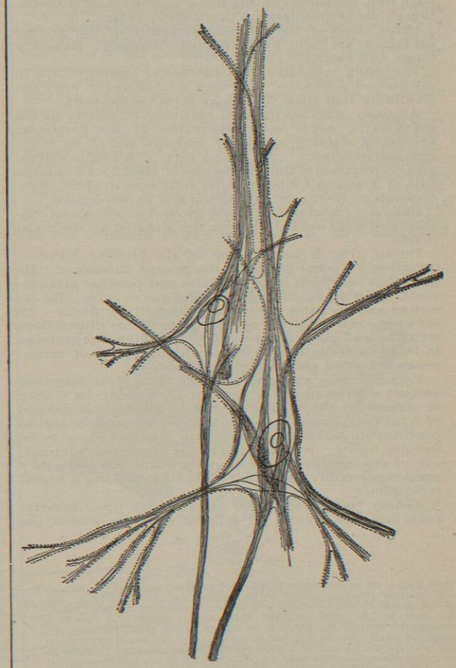

FIG. 927.—Neurofibrils in Pyramidal Cells of the Cerebral Cortex. (After A. Bethe, taken from A. Van Gehuchten's "Le système nerveux de l'homme," 3d ed., Louvain, 1900, vol. i., p. 302, Fig. 187.)

ess. Apáthy believes that the peripheral finer neurofibrils of the pear-shaped process are sensory and that the single central neurofibril of large calibre is motor.

The descriptions of Apáthy bearing upon the relations of the neurofibrils to sensory surfaces and to the constituent elements of muscular tissue and secreting glands do not concern us here. One important point, however, in connection with his work must be mentioned. He believes that the neuropilum of invertebrates is formed by a huge plexus of anastomosing neurofibrils. This plexus he designates as an "Elementargitter."

Bethe has been able to demonstrate similar fibrils within the protoplasm of the nerve cells of vertebrates, including human beings (Fig. 927). Bethe thinks that he can determine which neurofibrils conduct toward the cell and which conduct away from the cell. He finds that both kinds of fibrils occur in the dendrites of the cells, and argues that a dendrite accordingly carries both cellulipetal and cellulifugal impulses. It must be remembered that many do not believe that it has yet been proved that it is the neurofibril which is the actual conducting element in the nerve cell.

Bethe in the main accepts Apáthy's views concerning the structure of the neuropilum of invertebrates, but in opposition to Apáthy denies the occurrence of anastomoses between the individual fibrils.

Nissl accepts the doctrines of Apáthy and Bethe apparently without question and has carried their hypotheses much further than they themselves appear to have been willing to take them. According to a late hypothesis formulated by Nissl, neurofibrils exist outside of the nerve cells and their processes, these being especially abundant in the gray matter of the cerebral cortex. Nissl denies the interpretations of those who have worked with Golgi's method, of the findings met with in silver preparations, and asserts that a large part of the areas between the cell bodies in the cerebral cortex supposed by Golgi workers to be filled up by the multiple subdivisions of dendrites, axones, and collaterals are not in reality so made up, but consist of an immense number of naked neurofibrils situated outside of the cells; these fibrils, Nissl thinks, correspond in a sense to a highly complicated neuropilum. In support of his view he publishes comparative pictures of the motor area of the cerebral cortex of a man (Fig. 928), a dog (Fig. 929), and a mole (Fig. 930). The increased distance between the cells in the higher animals he believes to be accounted for by the increased amount of his hypothetical neuropilum. Nissl was led all the more readily to accept the views of Apáthy and Bethe inasmuch as Becker has also been able to demonstrate fibrillar appearances within "nerve cells" by hæmatoxylin staining.

Still another mode of demonstrating networks of a curious character within the bodies of nerve cells has been introduced by Golgi by a slight modification of his osmic bichromate method. A definite endocellular network apparently different from that described by any previous observer can be demonstrated (Figs. 931 and 932). Veratti has worked with the same method and has been able to impregnate networks in a variety of nerve cells similar to those described by Golgi.

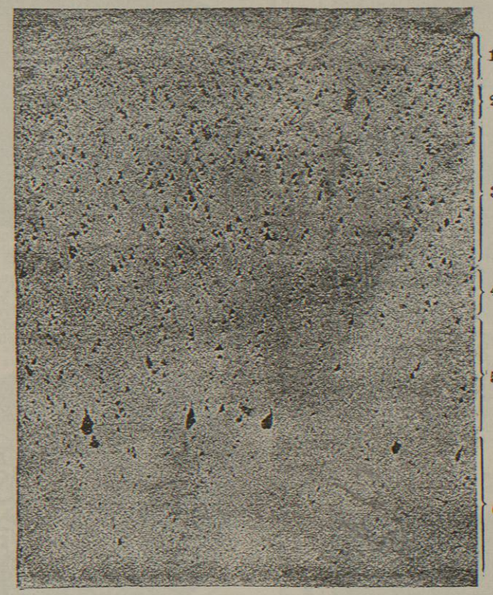

FIG. 928.—Reproduction of a Photogram of a Perpendicular Section through the Tip of the Head of the Gyrus Centralis Anterior, Close to the Falx, of a Healthy Adult Man. Staining by Nissl's method. I. Layer poor in cells. II. Layer of pyramidal cells, containing 2 = layer of small pyramidal cells (= 2. Meynert's layer) + 3 = layer of large pyramidal cells (= 3. Meynert's layer). III. Layer of small cells (= 4. Meynert's layer). IV. Internal (6) and external (5) zone of the layer of medullated fibres (= 5. Meynert's layer). The region marked 5 corresponds to the ganglion-cell layer of Hammarberg, and the region marked 6 to the spindle-cell layer. (After F. Nissl, *Münch. med. Wochenschr.*, Bd. xlv., 1898, S. 1027, Fig. 3.)

Nucleus.—The nuclei of the nerve cells of the brain agree in structure with those of nerve cells in general (Fig. 933). The nuclei are relatively large and pale, and present in preparations stained by Nissl's method a chromatic membrane and a large deeply staining nucleolus. There is, as a rule, an abundance of achromatic substance. In the nucleolus it is possible in methylene-blue preparations to make out minute deeply staining points, the *nucleoluli* of von Lenhossék. The nucleolus sometimes presents a vacuolated appearance. It is believed by many that each nucleolus consists of a delicate basophile external layer and a central non-basophilic substance. According to Scott each nucleolus is a vesicle with an oxyphile centre and a basophile periphery. In preparations stained by Held's method it is possible to make out in the achromatic parts of the nucleus, strands and masses which take the erythrosin stain. These strands and masses may correspond to the lanthanin of Heidenhain. Careful microchemical studies of the nuclei and nucleoli have been made by Levy. Levy was unable to find nucleoluli in nucleoli stained by Biondi's method. Scott believes that the basophile covering of the nucleolus contains both iron and phosphorus as does also the oxyphile nuclear substance. The latter is readily dissolved in pepsin and hydrochloric acid. It is altered but not dissolved by acids and alkalies, which liberate the iron from it. He believes that the tigroid masses of the cell protoplasm consist of chromatin that has diffused itself from the nucleus into the cytoplasm.

Various authors have proven that the nucleoli of the nerve cells change in size during functional activity. They are small when the cell is at rest, but increase in volume when the cells are active.

The so-called *supporting substances* of the nervous tissue of the brain consist of ependyma cells and neu-