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A GOLGI STUDY OF THE AMYGDALOID COMPLEX IN THE CAT

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Abstract. The neuronal structure of the amygdaloid complex was studied in cat with Golgi–Kopsch perfusion technique. Four types of neurons were distinguished: the projective neurons (longaxonal), with the structure being different in the area anterior, corticomedial and basolateral parts of amygdala; the Golgi IIa neurons (shortaxonal), observed in all nuclei of the amygdala; the Golgi IIb neurons ((mediumaxonal), mostly observed in the dorsal part of the lateral nucleus; the Golgi IIc, neuroglioform type of neurons with short but very profusely arborized axons, present exclusively in the ventrolateral area of the basolateral part of amygdala. In addition, some afferent fibers have been visualized in the basolateral part of amygdaloid complex.

INTRODUCTION

The amygdaloid complex is a heterogeneous structure. The findings of Johnston (24), Fox (16), Crosby and Humphrey (6), Koikegami (25) and Valverde (44) confirm the idea of the amygdaloid complex being divided into two parts: (i) corticomedial part, which is phylogenetically older and closely associated with the olfactory system (5) and with the stria terminalis as the main efferent pathway (43), and (ii) the basolateral one which is phylogenetically younger and mainly connected with the ventral amygdalofugal system (21, 43). The corticomedial part of amygdala in the cat brain includes the cortical, medial and central nuclei, whereas the baso-lateral part contains the basal magnocellular, basal parvocellular and lateral nuclei. The functional division of the amygdala is generally in agreement with the anatomical one. Previous physiological studies showed an association of the amygdala with the emotional behavior of animals. More recent electrophysiological and physiological investigations have revealed the existence of two different areas of the

amygdala (e.g., 17, 18, 45). The ventrolateral part of the amygdaloid complex is associated with strong inhibitory processes and the dorsomedial part with the positive alimentary and defensive reactions (7, 8, 11, 12, 14, 15, 19, 27-29, 31). Physiological investigations on alimentary reactions (9, 10, 13, 20) have also shown the lesions in the ventrolateral and dorsomedial part of the amygdala to bring about quite opposite effects.

The general pattern of the internal connections in the amygdaloid complex of cat brain was presented by Valverde (44). The observations of Valverde were made on preparations impregnated according to modification of the rapid Golgi method which can only be applied in very young animals. Taking into account the anatomical and physiological data mentioned above, in this study it was aimed to determine the detailed neuronal build-up and the connections inside the amygdaloid complex.

Our observations are based on several series of sections from the adult cat brains in which the structure of fully developed neurons with finally shaped dendritic and axonal ramifications could be observed.

MATERIAL AND METHOD

Brains of two or three months old cats were prepared by the Golgi-Kopsch perfusion technique, as modified by Szentágothai (37) and Tömböl (39, 40). The successfully impregnated blocks were embedded in celloidin and frontal serial sections of 100 to 120 μm thickness were cut.

On these preparations the various cell types of the brain, the finer details of neuronal elements including dendritic spines as well as terminal axonal arborizations could easily be studied semiquantitatively.

Photomicrographs of cells and fibers were made at different levels for their reconstruction.

Magnifications $\times$ 250 and $\times$ 500 were used.

The identification of particular amygdaloid nuclei was based on the Jasper and Ajmone-Marsan atlas (23) and nomenclature of Johnston (24) was used.

RESULTS

On the basis of our material prepared with Golgi–Kopsch technique, the following types of neurons could be distinguished in the amygdaloid complex:

1. The longaxonal, projective neurons according to Ramon-Moliners (33) classification the "radiate" type;

2. The Golgi IIa type neurons having small cell bodies, thin and poorly arborized dendrites with some spines on them, and with thin poorly arborized axons as long as the radius of the dentritic tree;

3. The Golgi IIb type neurons with medium size cell bodies, well-developed dendritic tree with numerous spines and axons surpassing in length the dendritic tree;

4. The Golgi IIc (neuroglioform) neurons characterized by small cell bodies, poorly arborized dendrites without any spines on them and short, but very richly arborized axons.

These types of neurons were observed either in various nuclei of the amygdala or only in their parts.

Area anterior of the amygdaloid complex includes the subtantia innominata, area anterior of the amygdala and the nucleus of the lateral olfactory tract.

Substantia innominata (Plate I)

This area is not clearly separated from the surrounding tissue. Its posterior part joins without distinct border the amygdaloid complex. There is a transitional zone, where neurons characteristic for both the substantia innominata and the amygdaloid complex can be observed.

The neurons of the substantia innominata (Fig. 1-6) resemble to some extent those of the reticular formation of the brain stem (26) (Fig. 1 and 6). The majority of the cells are of a fusiform shape. The average size of the larger cell bodies is about 12-20 μ, that of the smaller ones—about 9-15 μ in diameter. Dendrites of fusiform cells originate from both ends of the cell body. The main dendrites branch off dichotomously and give rise to straight, long secondary dendrites. They are poorly arborized and their length is nearly 500 μ. Both the main and the secondary dendrites are thick, the latter being covered with drumstick-shaped spines. The long thick axon of the fusiform cell originates either with a distinct cone from the cell body (Fig. 2 and 3), or from the main dendrite (Fig. 5). The initial axonal collaterals are sometimes observed, which originate off near the cell body (Fig, 2, 3 and 5) and terminate in its close vicinity.

Occasionally, large triangular cells are found in the substantia innominata, the size of which is about 30 μ in diameter. Their main dendrites originating on the angles of the cell body ramify irregularly. The secondary and further dendrites are covered with spines.

In addition, in this area, single, roundest, medium size neurons are observed, which are more charateristic for cortico-medial part of the amygdaloid complex (Fig. 4). Their dendritic tree has a fairly regular

spheric shape and characteristic drum-stick spines may be observed on the secondary dendrites.

Area amygdaloidea anterior (Plates I and II)

The area amygdaloidea anterior, adjacent to the substantia innominata includes a variety of cell types and fibers. In this region the cell-types and neuronal arrangements show the features of the amygdaloid complex, although the single fusiform cells, typical for the substantia innominata can also be observed (Fig. 10).

Three cell types can be distinguished according to their size: large, medium and small cells.

The large neurons (Fig. 8 and 9) have rather multangular-shaped cell-bodies, of about 24-27 μ in diameter. The thick dendrites originating from the cell arborize irregularly. The secondary dendrites are covered with spines. The long axon emerges from the cell-body and after giving off collaterals, turns dorsalward. This type of neuron was observed rather in the medial part of this area.

The medium size neurons (Fig. 7, 11, 13 and 14) are ovoid or multangular. The main dendrites are dichotomously arborized. Drum-stick-like spines are found on the secondary dendrites. The long axon originates from one of the main dendrites and is directed dorsally. It gives off several collaterals, which have a dense terminal arborization in the close vicinity of the cell body.

The small neurons have cell bodies of 10 to 15 μ in diameter (Fig. 12) and a few, rather long and poorly branched dendrites covered with spines. The thin axon originates from the cell body, but except for the initial part it is not impregnated. Taking into account the size of the cell body and the type of the dendritic tree, this cell might be considered as a Golgi II type neuron. Since, however, the axon did not impregnate, this assumption could not be corroborated. Large and medium size neurons belong to type of longaxonal, projective neurons.

Lateral olfactory tract

Two types of neurons were observed in this nucleus (Plate IV). One of them is the medium size projective neuron, ovoid or multangular in shape, with long axons (Fig. 15 and 17). The axon originates from the cell-body and after giving off collaterals (Fig. 17, see mark) it runs medially in the direction of the diagonal band of Broca. The dendritic tree of the projective neuron is irregular, the dendrites are thick and densely covered with drum-stick-like spines.

The other cell-type is a small Golgi II type neuron. After originating, the axon arborizes near the cell-body (Fig. 18, marked).

The corticomedial part of the amygdaloid complex contains: nucleus corticalis, nucleus medialis and nucleus centralis.

Cortical nucleus (Plates V and VI)

In the cortical nucleus three types of projective neurons and a Golgi II type interneuron were observed. The main cell type in this nucleus is a pyramid-like neuron with a strong apical and a few basal dendrites (Fig. 19-22). The apical dendrite branches at a further distance from the cell-body and is always directed toward the brain surface. The poorly ramified thin basal dendrites are arranged in a bunch at the basis of the cell (Fig. 19-21 and 28). Both basal and apical dendrites are covered with spines. The axon originates from the basal part of the cell-body and runs either toward the amygdaloid complex or to the stria terminalis. Some axons have collaterals which bend back to form local connections (Fig. 22).

The other type of a projective neuron is the fusiform neuron of 14-28 μ in diameter, with very long (300-400 μ), polarly situated dendrites (Fig. 25). The axon of the fusiform neuron originates from a dendrite and having given off collaterals it turns inward the amygdala.

In addition, the multangular projective neuron (Fig. 26) was observed in the internal part of the cortical nucleus, at the boundary with the basal nucleus. The thick axon originating in this neuron type from a main dendrite also runs toward the amygdala. The denrites are covered with spines.

The interneurons in the cortical nucleus are of the Golgi IIa type. These are small cells with cell bodies ranging in diameter from 10-15 μ. Only a few dendrites, covered with a small number of spines, originate from the cell (Fig. 23, 24 and 27). The axon arborizing in the vicinity of the neuron forms locally a terminal network characteristic for the Golgi II type neuron. This type of neuron was found to appear at various depths of the cortical nucleus.

Medial nucleus (Plate VII)

The medial nucleus is characterized by a distinct uniformity of the neurons (Fig. 29-32) which are rather small, ovoid, fusiform or angular in shape, with a diameter of 11 to 18 μ. They have a small number of long, poorly arborized dendrites with few dendritic spines. The long thin axon originates either from the main dendrite or from the cell body and is directed toward the stria terminalis. This means that the axons of cells situated in the dorsal part of the nucleus run ventrally (Fig. 29, 30 and 32). Even when directed dorsally at their origin they turn in the ventral direction after a short course (Fig. 29 and 30). The axons of the cells

situated in the ventral part of the nucleus are directed dorsally (Fig. 31). Some of the axons have collaterals, which enter the basal nucleus and ramify there (Fig. 30).

Central nucleus (Plates VIII and IX)

In this nucleus one can clearly distinguish the lateral part, consisting of small ovoid cells and the medial part, consisting of large irregular, multangular cells. Unfortunately only the initial parts of axons of both neuron types can be observed, which may have resulted either from unsuccessful impregnation or from the fact that the residual parts were situated beyond the level of the section.

As far as the dendritic trees are concerned two types of small, ovoid neurons may be distinguished in the lateral part. Ovoid shaped cells (13-14 μ in diameter) with very thick profusely arborizing dendrites of approximately 300 μ length appear to be more numerous. Their secondary dendrites are covered with drum-stick-like spines. The axons originating from the cell body, take a dorsal course and appear to be free of collaterals (Fig. 33 and 34). Sometimes neurons of the same type are seen to have larger cell bodies (about 14-18 μ in diameter) (Fig. 35). The small neurons of the other type have few thin dendrites (Fig. 36 and 37) with only very few spines to be observed thereon.

In the medial part of the central nucleus, there are some scattered irregular large cells (Fig. 38 and 39). Their dendrites are thick, long (about 350 μ) and poorly branched. Only few spines can be observed on the secondary and further dendrites. The initial part of the axon, directed dorsally, is well discernible.

The baso-lateral part of the amygdaloid complex contains the following nuclei: basal magnocellular (dorsal) nucleus, basal parvocellular (ventral) nucleus and lateral nucleus.

Basal magnocellular (dorsal) nucleus (Plates X, XI and XII)

Two cell types were observed in the basodorsal nucleus, characterized by their axonal patterns: a neuron with long axon and a Golgi II type neuron. The first type is a large projective neuron. The diameter of the cell body is about 20-30 μ. The dendritic tree of these cells ir rather irregular. The main dendrites arise from the cell-body and after a short course (about 10-20 μ) arborize mostly dichotomously. The radius of the dendritic tree is about 250-300 μ. The secondary and further dendrites are densely covered with drum-stick-form spines (Fig. 40-43).

The other cell type, a Golgi II type neuron is functionally an interneuron. The small cells are scattered among projective neurons. The

diameter of their cell-bodies ranges from 14 to 19 μ. They are ovoid in shape and their dendrites — with few exceptions — are of polar origin. The main dendrites are very short. They ramify at a distance of about 10-15 μ from the cell body and the spines on their secondary dendrites are less densely arranged. The axon (Fig. 44-47) originates generally from the main dendrite, and arborizes dichotomously in the vicinity of the neuron, not extending over the dendritic tree. The fine terminal part of the arborized axon could not be observed; one might, however, suppose that this cell-type establishes local connections.

It is possible — although very rarely — to observe afferent fibers in the Golgi–Kopsch preparations. Figure 48 shows impregnated afferent fibers and their diagram, in the baso-lateral part of the amygdaloid complex. The fibers, having entered dorsally the nucleus, are directed ventralwards, where some of them arborize in a fairly extended area, forming a fine terminal network. However, neither their terminal knobs nor contacts can be seen.

Basal parvocellular (ventral) nucleus (Plates XIII and XIV)

In this nucleus, just as in the basal magnocellular nucleus, two types of neurons were observed: the projective neuron with long axon, and the Golgi II type neuron with short axon. In addition, a special Golgi II type neuron was also observed.

The projective neurons, found in all parts of the nucleus, are of medium-size. The cell body is about 20-24 μ in diameter. They form a large, dense dendritic tree, their secondary dendrites being covered with spines. The axons of this type of neurons, originating from the cell body run either dorsally or ventrally, often giving off collaterals (Fig. 49-53).

The other type of neuron is a Golgi II type neuron shown in Fig. 49 and 54. From a rather small cell body a few, poorly branching long dendrites are originating with a few spines on them. The thin axon ramifies at a short distance after leaving the cell body.

A rather peculiar kind of neuron is found in the ventral and ventrolateral part of this nucleus (Fig. 55). These neurons are characterized not only by a very small cell body, but also by a dendritic tree covering only a small area. The length of thin and poorly ramified dendrites is about 120-150 μ. The dendrites have a various course and are virtually free of spines. The axon starts from the cell body and after a very short course (20-25 μ) ramifies profusely. The axon is characterized by an extremely dense arborization and its secondary and further branches are very thin and impregnate varicously. The dense axonal arborization is of about the same radius as the dendritic tree. Because of its fine and dense axon-arborization and "non characteristic" dendritic tree, this neuron, at the

first sight, resembles a neuroglial cell, but examined more thoroughly the axon can be clearly distinguished. Cajal (4) described this type of neuron in the basal ganglia as a neuroglioform cell. Its axon possessing such a rich arborization is presumably able to establish numerous local connections.

Lateral nucleus (Plates XV–XXI)

The greatest variety of morphological elements were observed in the lateral nucleus. Four cell types could be distinguished in this part of the amygdaloid complex: a projective neuron, having a long axon that leaves the amygdaloid complex, and three subtypes of Golgi II neurons. The "projective neurons" have perikarya of various shape and size. The smaller neurons have cell bodies of 18-24 μ in diameter, the larger ones of about 20-30 μ. Five to eight main dendrites originate from the cell body and branch dichotomously. The length of these dendrites is about 250 μ. The secondary dendrites are densely covered with drum-stick like spines. The axons of these neurons are running either dorsally (Fig. 56-59) or in the ventral direction (Fig. 60 and 61). The axons give off collaterals branching in the surrounding.

The three subtypes of Golgi II type neurons found in this nucleus are the Golgi IIa, the neuroglioform and the Golgi IIb type neurons.

The Golgi IIa type neurons are shown in Fig. 62 and 63. They are scattered throughout the whole lateral nucleus. Dendrites originate from the small cell body with a thick, short stem, which ramifies dichotomously. The branches of dendrites are not numerous and on the secondary dendrites a few spines can be observed. The axon originates from the main dendrite and arborizes after a short course.

Figures 64 and 65 show the neuroglioform neurons described above in the basal ventral nucleus. These neurons were seen in the ventral part of the lateral nucleus. Their dendritic arborizaton seems to be somewhat richer, than that of the same cell-type in the basal ventral nucleus. On the secondary dendrites no spines were observed either. The short axon arborizes abundantly, like it does in the basal ventral nucleus.

The fourth cell type was observed in the central and dorsal part of the lateral nucleus. The cell body of these neurons is of medium size (22-24 μ in diameter) and multangular in shape (Fig. 66 and 67). It has some strong dendrites which bifurcate several times. The secondary dendrites are covered with spines. The axon originates from the main dendrite and at a distance of about 150 μ it splits into two branches. One of them seems to arborize in the lateral nucleus, the other runs dorsomedialward and seems to leave the nucleus at some distance. This type of

neuron appears to form internuclear connections within the amygdaloid complex.

In the lateral nucleus some afferent fibres could be observed, which differed from each other in thickness, direction and arborization pattern. Neither could the origin of these fibers be identified nor their contact with the amygdaloid neurons detected. Their course and entrance into the amygdaloid complex, as well as the arborization pattern were the only details to be observed. Figures 68, 72 and 74 show different fibres entering the lateral nucleus ventrally. The thickest of them (Fig. 68), run dorsally without lateral branches and have a number of short terminal branches. The other fibers (Fig. 72) have a rich arborization and fine terminal ramification extending in the mediolateral direction. Figures 69 have fine lateral branches. Figure 70 demonstrates a thin fiber with terminal ramification extending in the mediolateral direction. Figures 69 and 71 show terminal parts of fibers running in dorsoventral direction. Short spine-like side-branches are seen on the terminal part of the fibers. A medium thick fiber is seen in Fig. 73. It is directed dorsoventrally and has fine terminal and lateral branches.

Plate XXI demonstrate various contacts of fibers with neurons. The termination of an axon-collateral near the main dendrite of another cell can be observed (Fig. 75). Fine terminal branches appear to terminate in the main dendrite (Fig. 76), in the cell body and at the dendritic arborization (Fig. 77). Fine terminal fibers appear to have also contacts with the dendritic spines (Fig. 78).

Intercalate nuclei (Plates XXII and XXIII)

Groups of very small neurons are situated between the basal and medial nuclei and also between the central, basal and lateral nuclei. These cell-groups are often embedded in bundles of fibers running in the medial and dorsal directions. Most of these cells are ovoid or fusiform in shape with cell body diameters of about 10-15 μ and with long polarly arranged dendrites. The secondary dendrites are covered with spines. The polar arrangement of dendrites probably depends on their position. The axons originate from the cell bodies and run either dorsally, entering the central nucleus where they arborize like other Golgi II type neurons (Fig. 81), or at first laterally giving off the collaterals (Fig. 79) and then entering the central nucleus.

Within the intercalate nucleus situated between central and basal dorsal nuclei, single, somewhat larger cells were also observed. These cells are characterized by extremely long (up to 800 μ) dendrites arranged in mediolateral direction, and covered with spines (Fig. 83).

DISCUSSION

According to Johnston's traditional classification (24) three parts can be distinguished in the Golgi preparation: the corticomedial and basolateral parts and also area anterior of the amygdaloid complex. From the point of view of the neuronal structures area anterior is a transitional zone, mostly composed of medium size fusiform neurons but also of single large cells. The corticomedial part is mostly composed of small neurons, characterized by their remarkable uniformity. The basolateral part and particularly the lateral nucleus includes different types of neurons.

Projective neurons were observed in all amygdaloid nuclei except the intercalate nucleus. In the main parts of the amygdaloid complex the projective neurons differ from one another especially in the size of cell bodies and in their dendritic arborization. The projective neurons in all parts of the amygdaloid complex have as a common morphological feature, a long axon which leaves the amygdaloid complex and seems to establish connections with other regions.

In the medial nucleus the projective neurons have small cell bodies and a few, poorly ramifying dendrites. The axons are thin and collaterals seen occasionally.

In the cortical nucleus the projective neurons are similar to those in the medial nucleus, the specific character of the nucleus is, however, determined by the presence of pyramid-like cells with axons always directed inward the amygdala. The neighboring cells of the piriform cortex are also sending their axons or axon collaterals into the ventral part of the amygdala (44). In spite of this similarity the cortical nucleus cannot be identified with the piriform cortex, because of the lack of lamination typical for the latter.

The cell bodies of the projective neurons in the central nucleus are as well small although somewhat larger than in the above mentioned nuclei. The axons are thin but the dendrites are more numerous and more abundantly arborizing. On the secondary dendrites more spines can be observed than in the other cortico-medial nuclei of the amygdala. This fact may be due to the presence of a different type of terminal arborization and synaptic system of afferent fibers.

Hall and her colaborators (22) impregnating brain sections with heavy metal salts, has shown that the central nucleus is one of the areas in the amygdaloid complex, where probably some afferent systems terminate. Valverde (44) has reported the central nucleus in rat and mice brain to be the area of termination of the afferent fibers of stria terminalis.

In the basolateral part of the amygdala the projective neurons are characterized by large cell bodies, well developed dendritic trees with numerous spines and thick axons with collaterals. No axon collaterals

were observed in the basal magnocellular nucleus. This was probably due either to the incomplete impregnation or to the fact that the axons were situated perpendicularly to the plane of cutting. Mukhina and Leontovich (32) have observed in the same part of the dog amygdala neurons with long axons giving off colaterals.

The Golgi IIa type neuron was observed in all nuclei of the amygdala, more frequently in the baso-lateral than in the corticomedial part. This type of cell was described by Cajal (4) as a Golgi II type neuron. This neuron was shown by means of different methods (30, 34, 35) to be present in various parts of the central nervous system and was functionally identified in the specific thalamic nuclei (39-42). Our preparations did not permit the determination of the connections of Golgi II type neurons in the amygdaloid nuclei. According to the observations of Szentágothai (38) and Tömböl (40, 41) in specific thalamic nuclei the axons of Golgi IIa neurons terminate on the projective neurons of the same nucleus. On the other hand, the axon collaterals of the projective neurons are ending on Golgi IIa type neurons. In the thalamus these local connections between the projective and Golgi IIa type neurons provide the anatomical basis of a recurrent inhibition (1-3). One might suppose that the Golgi IIa type neurons in the amygdaloid complex have a similar function.

The third cell-type is the *Golgi IIb type neuron,* which has a larger cell body and an axon surpassing in length the dendritic tree (42). This type of neuron was the most frequently observed in the dorsal and medial parts of the lateral nucleus.

Valverde (44) described this type of neuron in the amygdaloid complex and characterized it as a neuron interconnecting the different nuclei of amygdala. This was confirmed in the present observation showing the axons of Golgi IIb type neurons of the lateral nucleus to run to and arborize in the basal dorsal nucleus.

The fourth cell-type is *the neuroglioform neuron.* It is in fact a Golgi II type neuron with a small cell body and a short axon arborizing in the close neighborhood. On the poorly ramified dendrites no spines were observed. The neuroglioform neuron was described by Cajal (4) in the corpus striatum. This cell type was observed only in the ventral part of the lateral nucleus and in the lateral part of the basal ventral nucleus. It is known from the physiological and electrophysiological experiments (7, 10, 13-15, 31, 36) that the ventrolateral area of the amygdala exerts a strong inhibitory effect in which neuroglioform neurons might be involved.

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PLATE I

Neurons of the substantia innominata

Explanation of Figures

1 Fusiform projective neurons of substantia innominata. Dendrites dichotomously branched and secondary dendrites covered with drum-stick like spines. × 250.

2, 3 Axons of fusiform cells originating from the cell bodies have initial collaterals (see arrows). × 250.

4 Medium size, multiangular, projective neuron with spheric shaped dendritic tree. × 250.

5 The axonal collateral of fusiform cell richly arborized in the vicinity of the cell body (see arrow). × 250.

6 Group of fusiform and multangular projective neurons arranged in various directions. × 250.

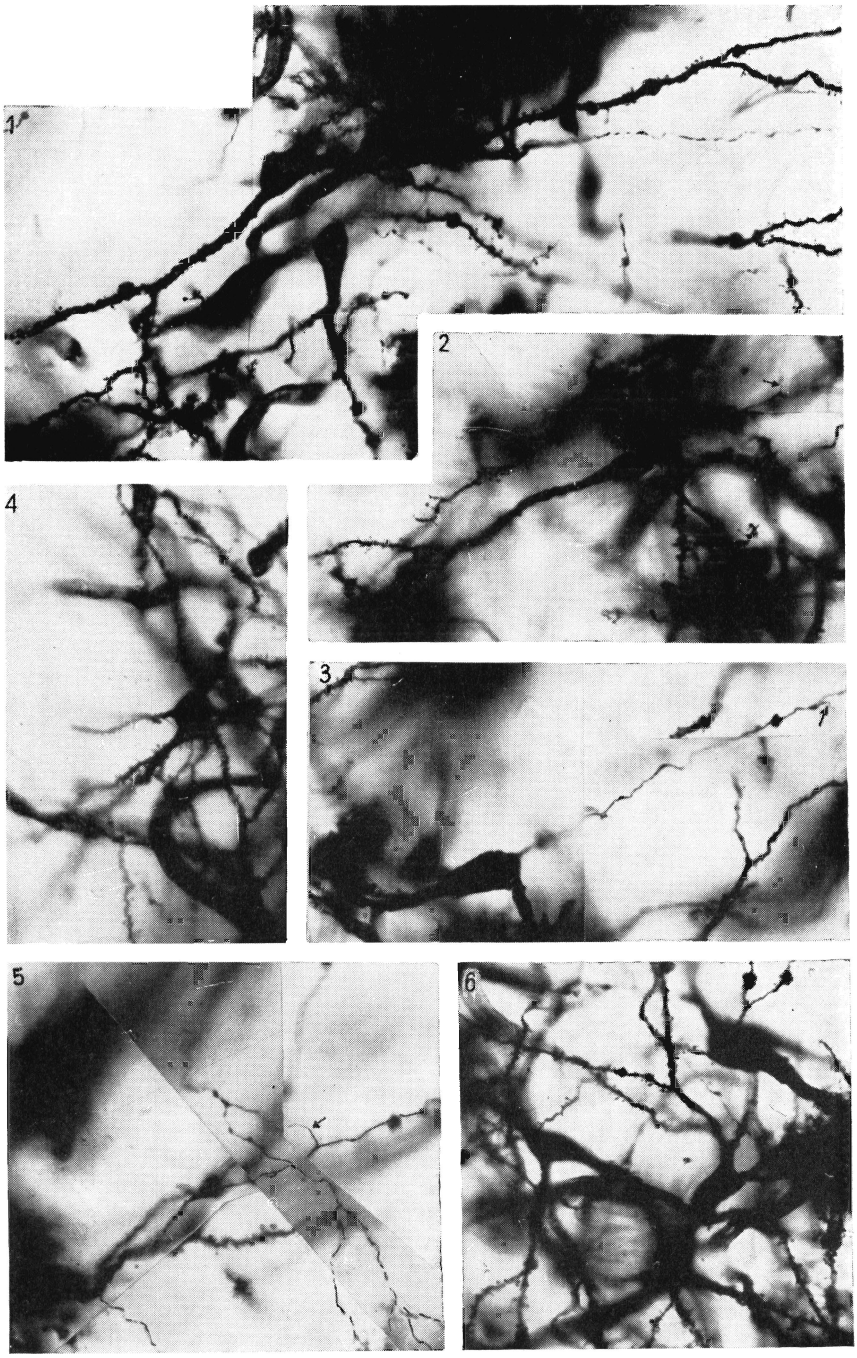

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PLATE II

Neurons of the area amygdaloidea anterior

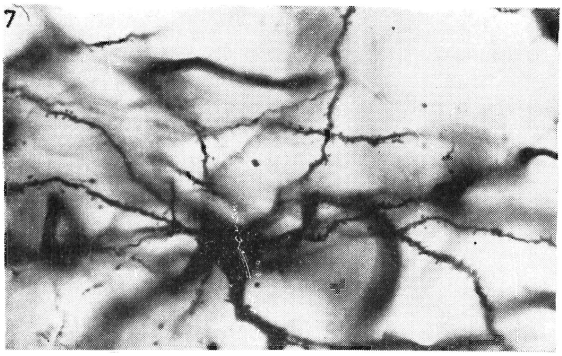
Explanation of Figures

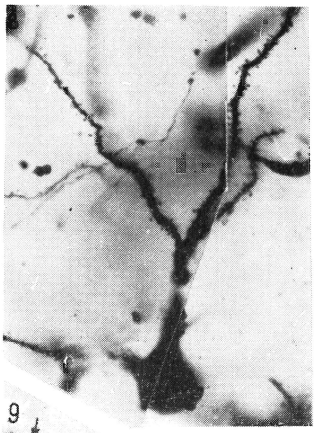
7-9 Large multangular projective neurons of area anterior. Dendrites dichotomously arborized and secondary dendrites covered with spines (Fig. 8). The axon originating from the cell body has initial collaterals (see arrows) (Fig. 9). × 250.

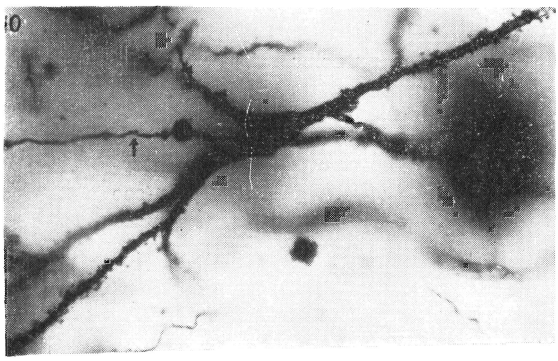
10 Fusiform neuron in area anterior. Secondary dendrites covered with spines. Axon runs in the medial direction (see arrow). × 250.

11 Medium size ovoid neuron. Dendrites dichotomously arborized and secondary dendrites covered with spines. × 250.

12 Small neuron with poorly branched dendrites. × 250.


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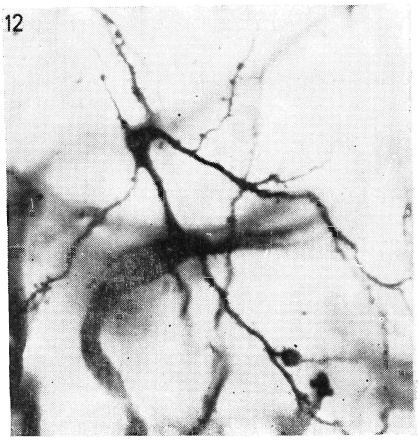

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PLATE III

Neurons of the area anterior

Explanation of Figures

13, 14 Group of projective neurons in this area. Long axons run in the medial direction and have initial collaterals which arborized in the vicinity of the axon (see arrows). × 250.

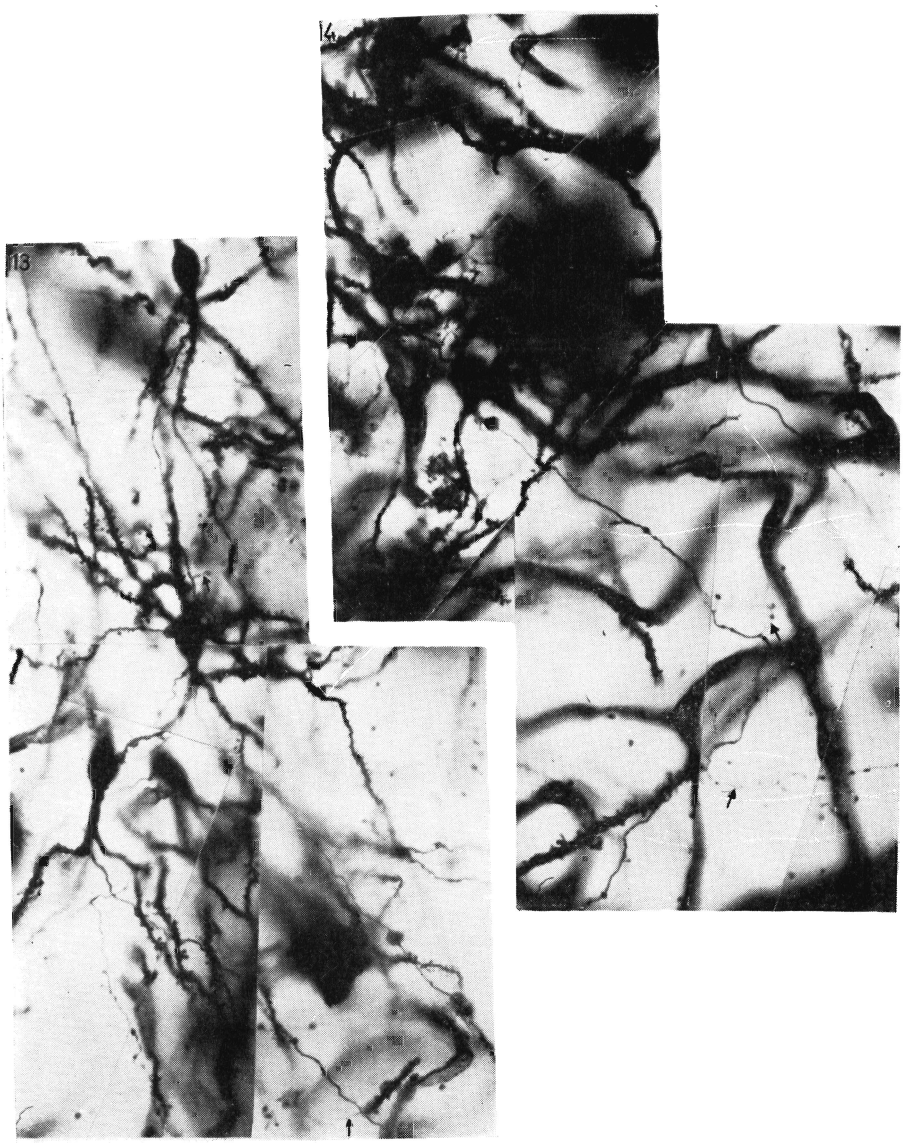

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PLATE IV

Neurons of the nucleus of the lateral olfactory tract

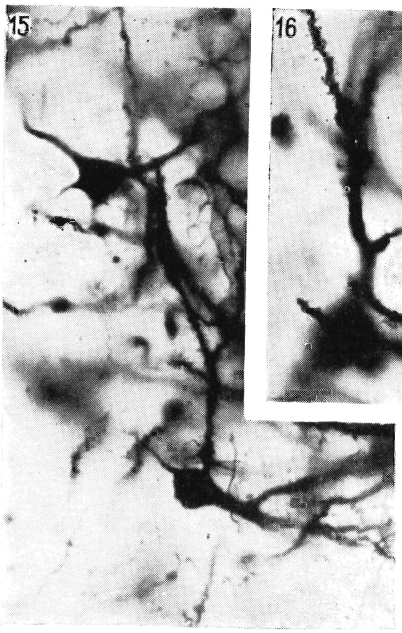
Explanation of Figures

15. Medium size ovoid projective neurons with thick irregularly shaped dendrites. × 250.

16 Strong dendrites of this neuron type with drum-stick-like spines on the secondary dendrites. × 500.

17 Thin axon of this neuron type with initial collaterals (see arrow). × 250.

18 Golgi IIa type neuron. Arrow shows the arborization of axon near cell body. × 250.


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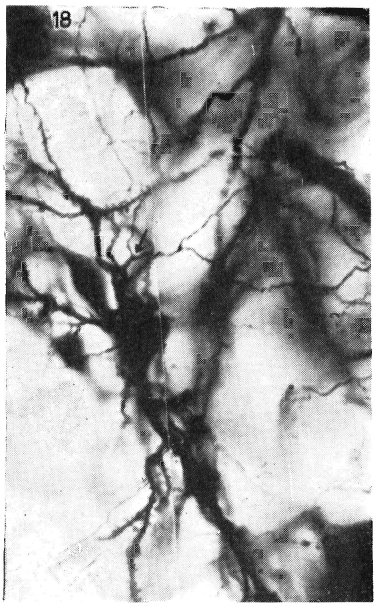

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PLATE V

Neurons of the cortical nucleus

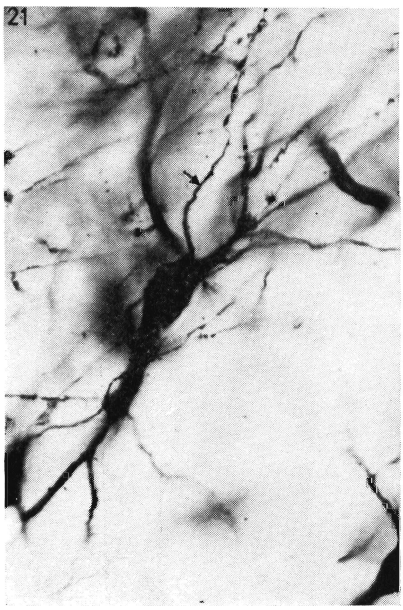
Explanation of Figures

19-21 Pyramid-like projective neurons with strong apical dendrites and a bunches of thin basal dendrites. The axons originating from the basal parts of cell body direct into amygdala. (see arrows). × 250.

22 Pyramid-like neuron. The arrow indicates a recurrent collateral of the axon. × 250.


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PLATE VI

Neurons of the cortical nucleus

Explanation of Figures

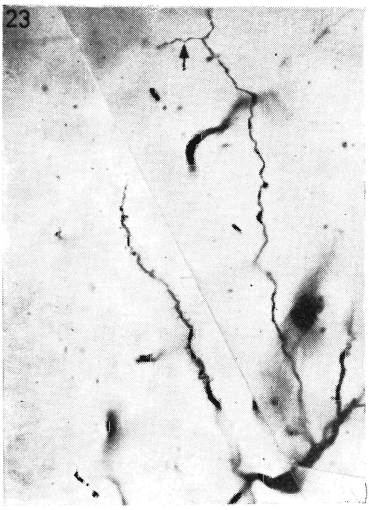
23, 24 Golgi IIa neurons. Arrows show the ramification of axons. × 250.

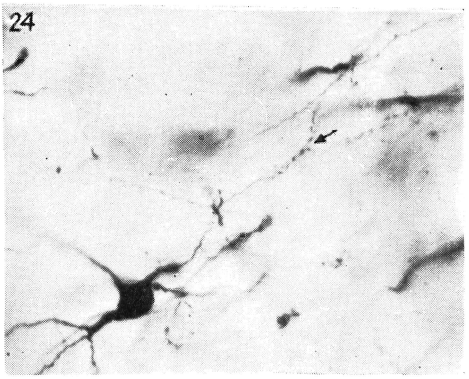
25 Medium size fusiform, projective neuron. Arrow shows the initial axonal collateral. × 250.

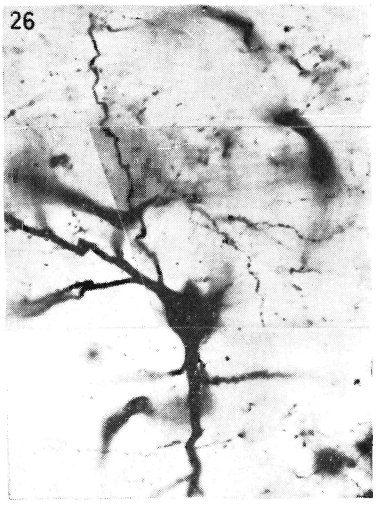
26 Medium size triangular neuron located on the boundary with basal parvocellular nucleus. The axon originating from the main dendrite runs inward the amygdala. × 250.

27 Small ovoid cell with thin axon which directs to the brain surface. × 250.

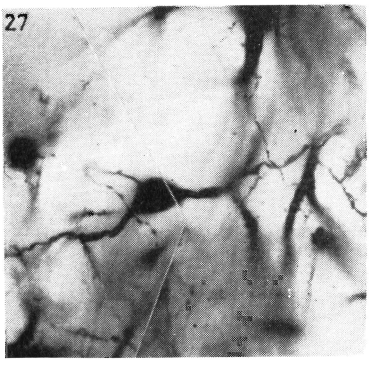
28 Group of cells in the cortical nucleus. × 250.


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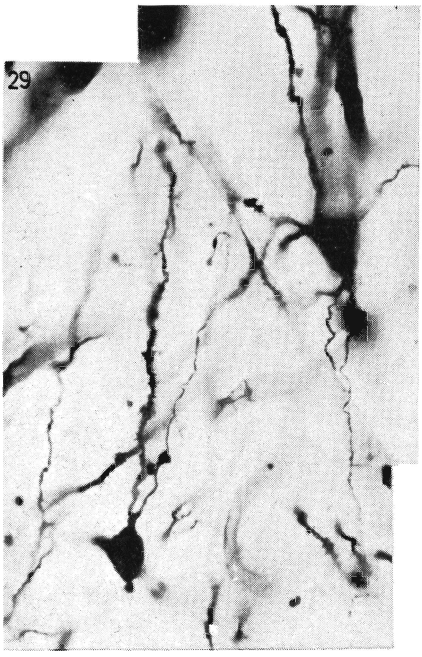

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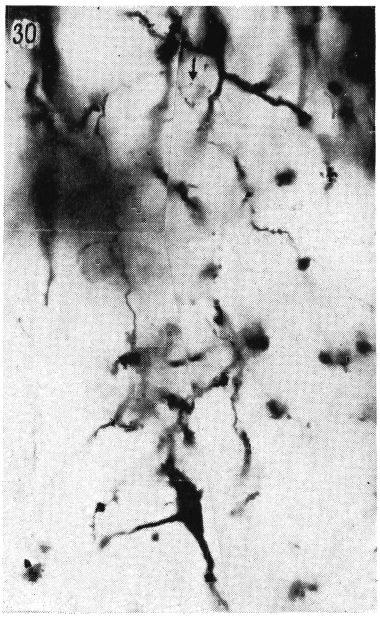
PLATE VII

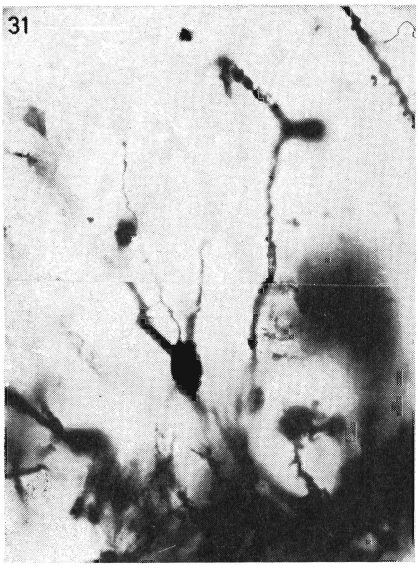
Neurons of the medial nucleus

Explanation of Figures

29-32 Small ovoid, fusiform and angular projective neurons with poorly arborized dendrites and thin axons. Arrow (Fig. 30) indicates the ramification of axonal collateral. × 250.


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PLATE VIII

Neurons of lateral part of the central nucleus

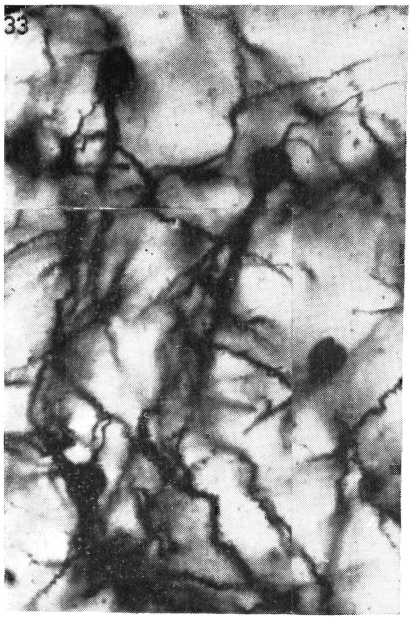
Explanatien of Figures

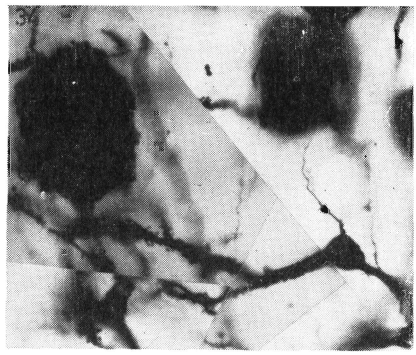
33 Group of most numerous and characteristic cells for lateral part of the central nucleus. × 250.

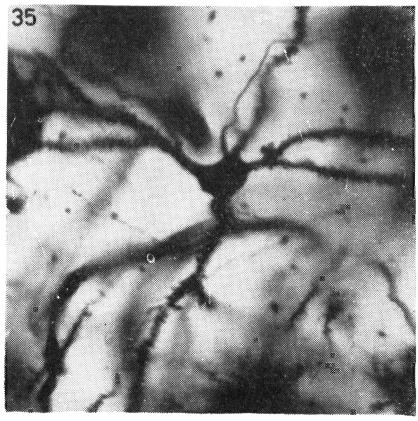
34 Small ovoid neuron with strong and spiny dendrites and thin axon directed dorsally. × 250.

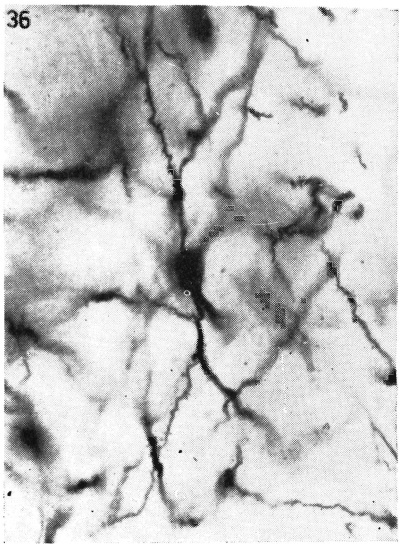
35 Small multangular neuron with well developed dendritic tree and spines on the secondary dendrites. The axon originating from the cell body directs dorsally. × 250.

36, 37 Small, ovoid neurons with thin and poorly arborized dendrites. × 250.


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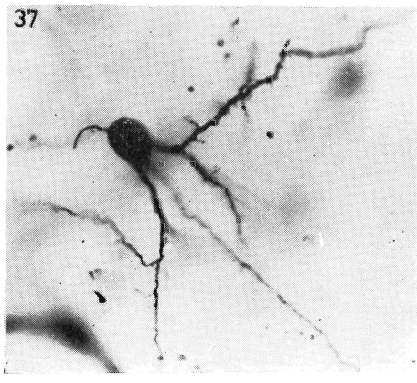

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PLATE IX

Neurons of medial part of the central nucleus

Explanation of Figures

38, 39 Irregular shaped, large neurons. Initial parts of axons directed dorsalward.


38

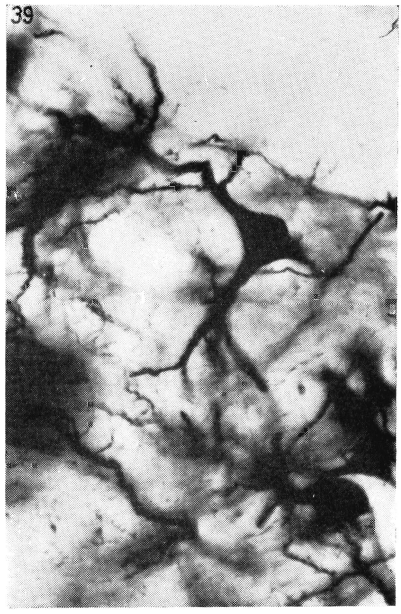

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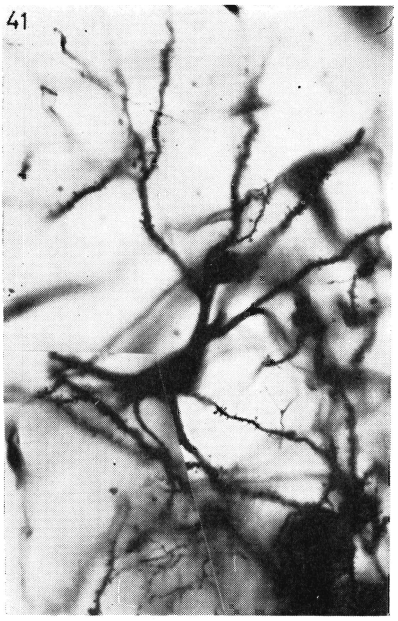
PLATE X

Neurons of the basal magnocellular (dorsal) nucleus

Explanation of Figures

40-43 Large multiangular projective neurons with well developed dendritic tree. The secondary dendrites covered with spines. Strong axons run dorsally or ventrally. × 250.


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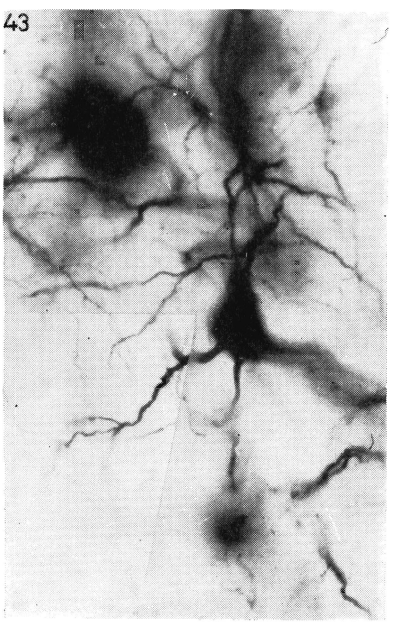

43

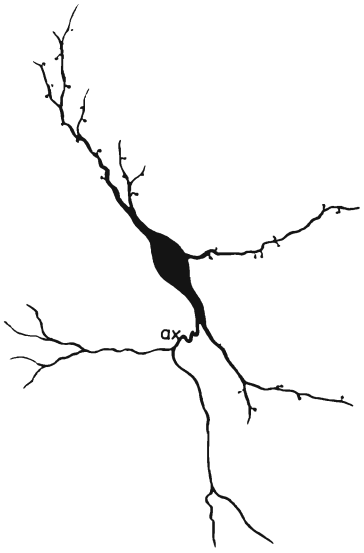
PLATE XI

Golgi IIa type of neurons in the basal magnocellular nucleus

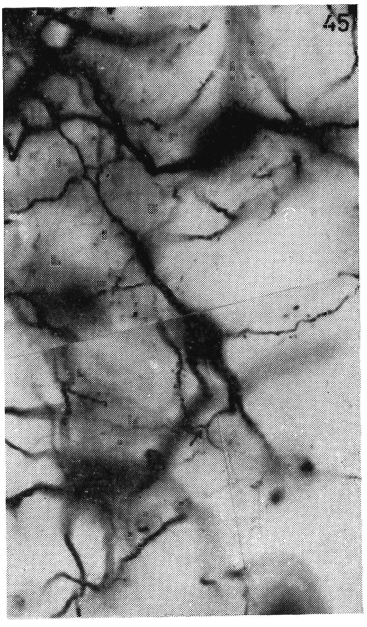
Explanation of Figures

44-47 Small ovoid shaped cell bodies with short axons which arborized near the cells. Arrows indicate the axon ramifications. × 250.

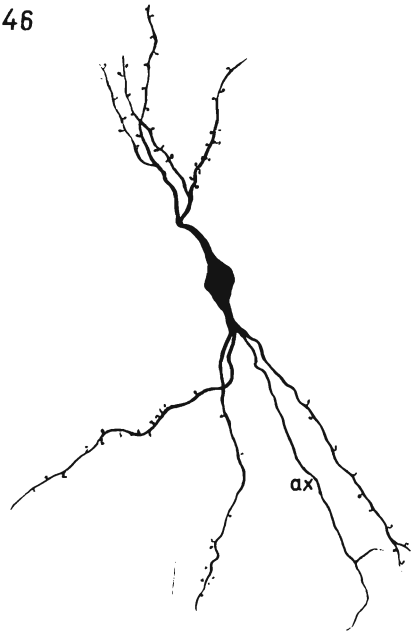
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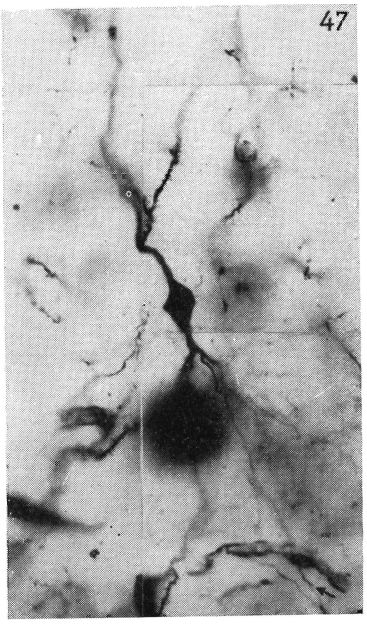


PLATE XII

Afferent fibers in the basal magnocellular nucleus

Explanation of Figures

48 Pattern of preterminal axonal arborizations of the afferent fibers. × 250.

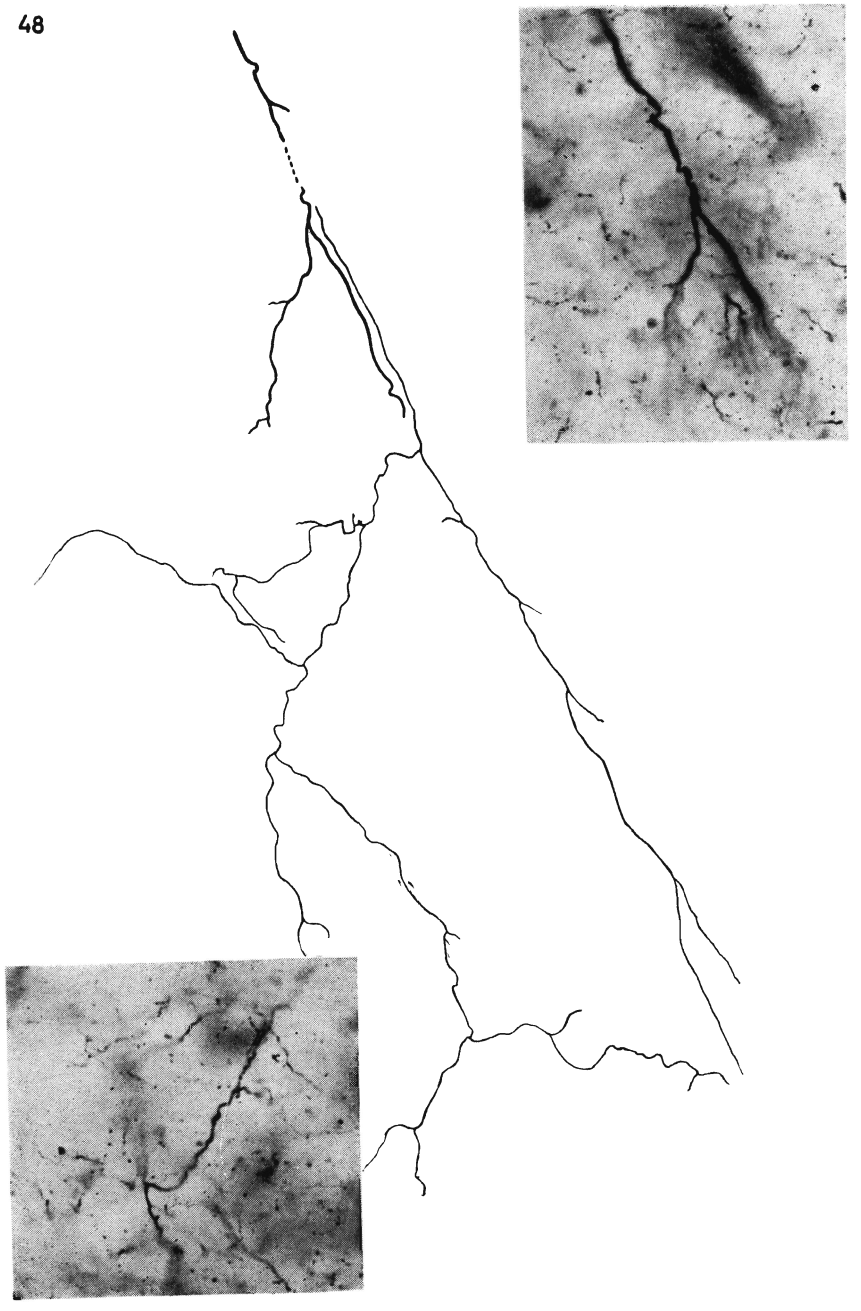

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PLATE XIII

Neurons of the basal parvocellular (ventral) nucleus

Explanation of Figures

49 Group of neurons — projective (large cells) and Golgi IIa (small cell). Arrow indicates the axon arborization of a Golgi IIa neuron. × 250.

50 Medium size ovoid projective neuron with long thin dendrites. × 250.

51 Medium size triangular projective neuron. The axon originates from the cell body. × 250.

52 Axon of this neuron type with initial collaterals (see arrow). × 250.

53 Medium size ovoid neuron in ventral part of the nucleus (just above the cortical nucleus). × 250.

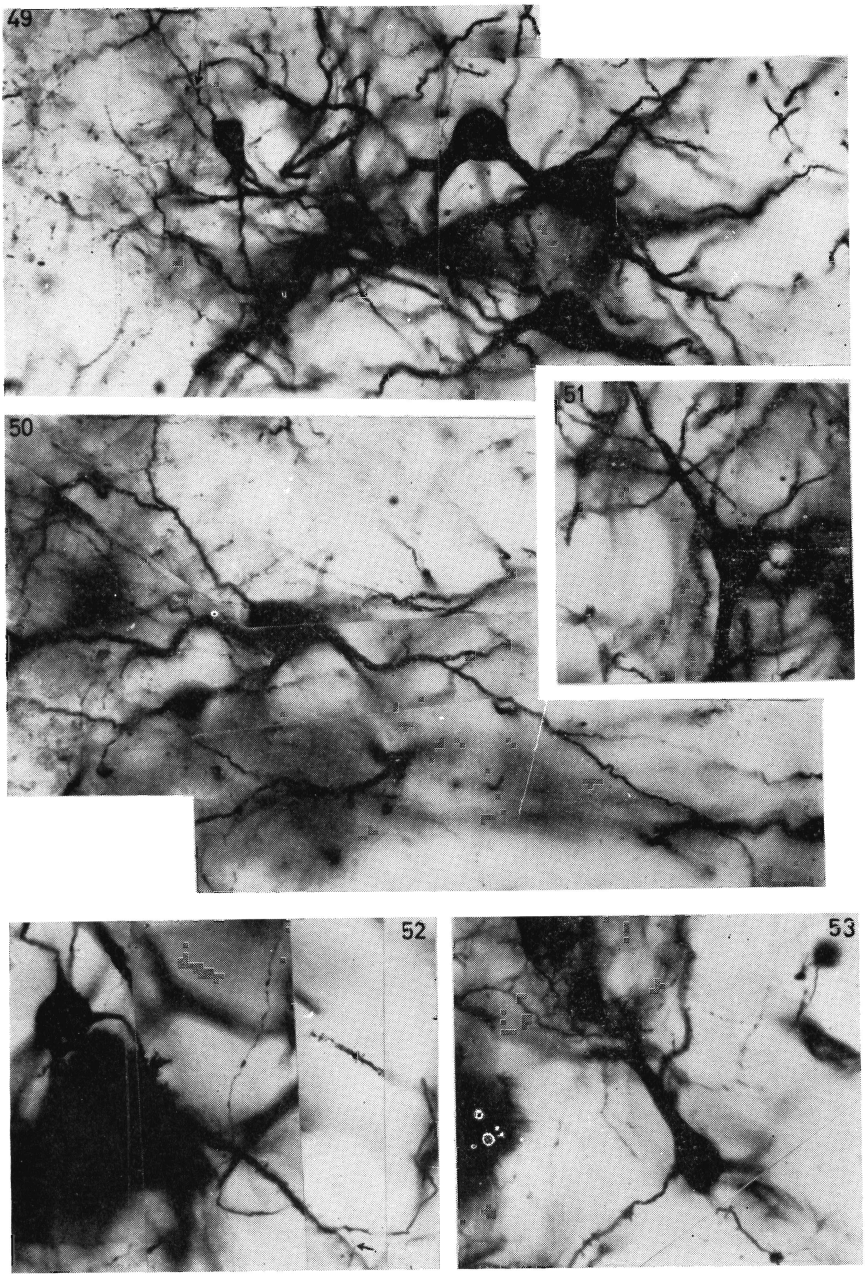

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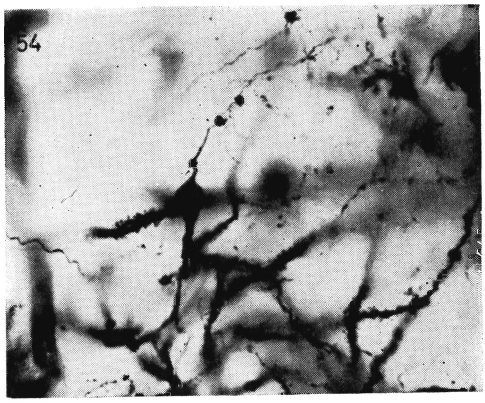
PLATE XIV

Golgi II type of neuron in the basal parvocellular nucleus

Explanation of Figures

54 Small, ovoid Golgi IIa type neuron with thin short and poorly arborized axon. × 250.

55 Golgi IIc type of neuron (neuroglioform) has small cell body with a few dendrites without any spines on them. Axon is extremely densely arborized (see arrow). × 250.


54

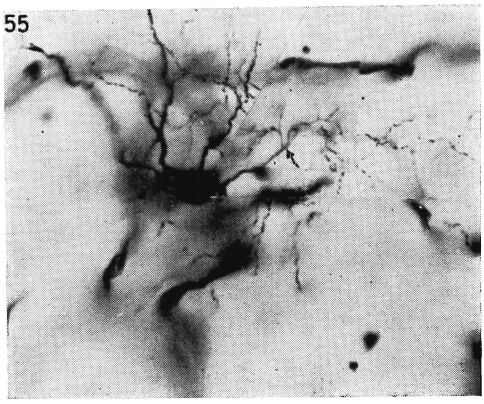

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PLATE XV

Neurons of the lateral nucleus

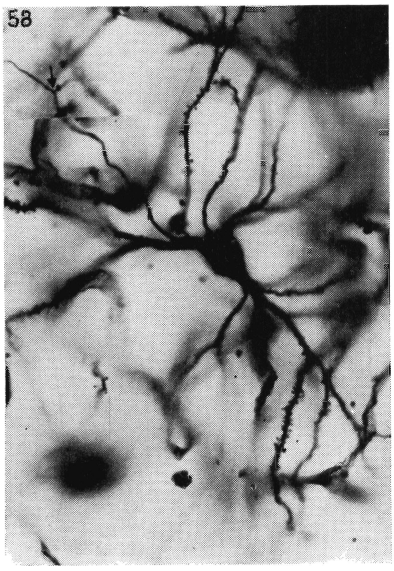
Explanation of Figures

56, 57 Medium size triangular projective neurons with well developed dendritic tree. The secondary dendrites covered with numerous spines. The axons run dorsalward and have many initial collaterals (see arrows). × 250.

58, 59 Medium size ovoid projective neurons with well developed dendritic tree. The secondary dendrites covered with spines. The axons run dorsalward and also have initial collaterals (see arrow). × 250.




57


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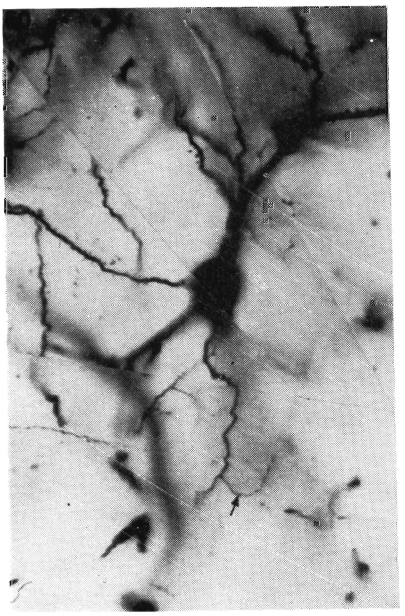

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PLATE XVI

Neurons of the lateral nucleus

Explanation of Figures

60, 61 Large projective neurons. The axons direct ventralward. Arrow points to the initial collateral. × 250.



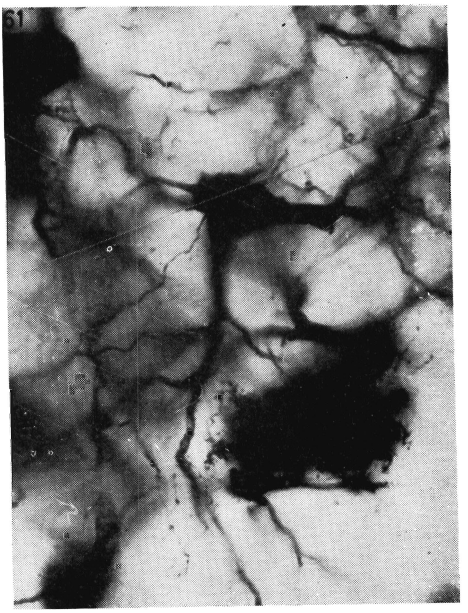


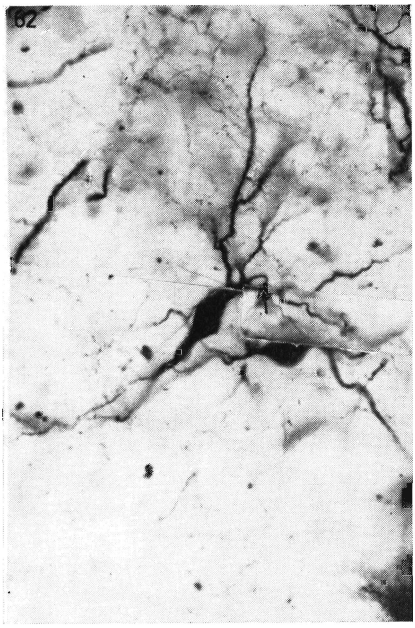
PLATE XVII

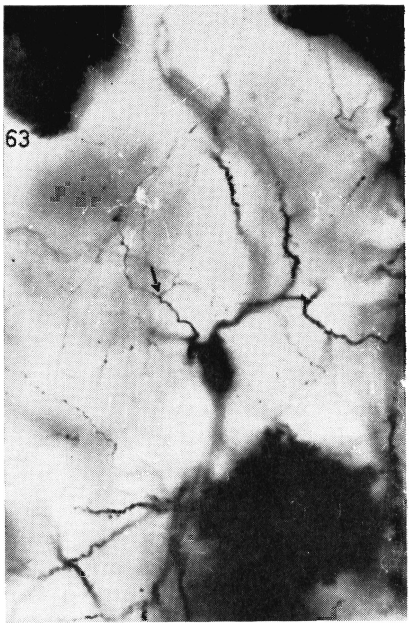
Golgi II neurons in the lateral nucleus

Explanation of Figures

62, 63 Golgi IIa type neurons in the lateral nucleus. Arrows show the ramification of axons. × 250.

64, 65 Golgi IIc type neurons (neuroglioform). Dendrites without any spines on them. The axons are richly arborized. Arrows point to the axon ramifications. × 250.


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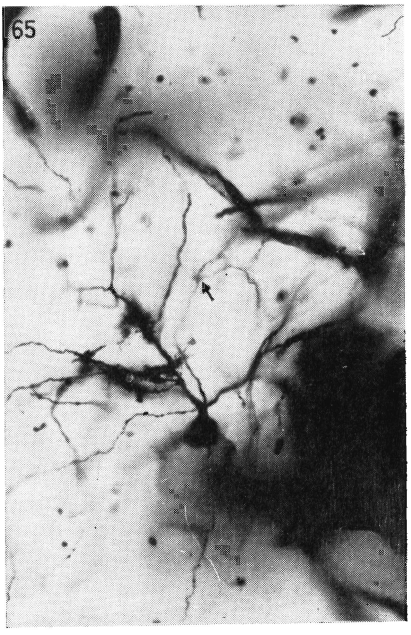
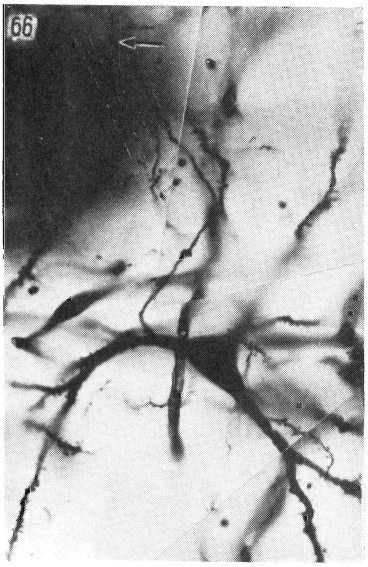

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PLATE XVIII

Golgi IIb neurons in the lateral nucleus

Explanation of Figures

66, 67 Medium size cell body, well developed dendritic tree with numerous spines on secondary dendrites. Arrow indicates the axon branching. × 250.


66

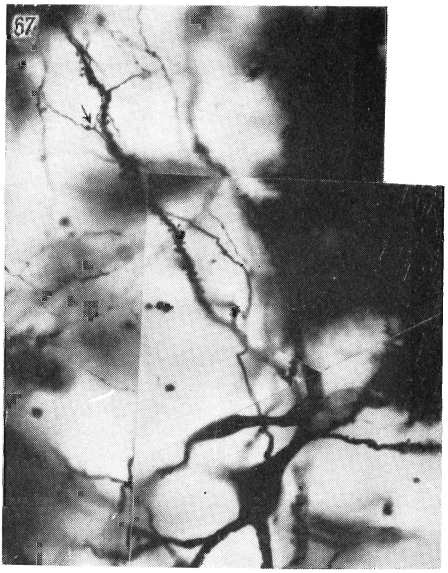

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PLATE XIX

Patterns of preterminal arborizations of afferent fibers in the lateral nucleus

Explanation of Figures

68 Thick afferent fiber entering ventrally the lateral nucleus. × 250.

69 Preterminal arborization of a medium thick afferent fiber which enter dorsally the lateral nucleus. × 250.

70 Preterminal arborization of a fine afferent fiber which runs in the medio-lateral direction. × 250.

71 Preterminal arborization of a thin afferent fiber which enters dorsally the lateral nucleus. × 250.

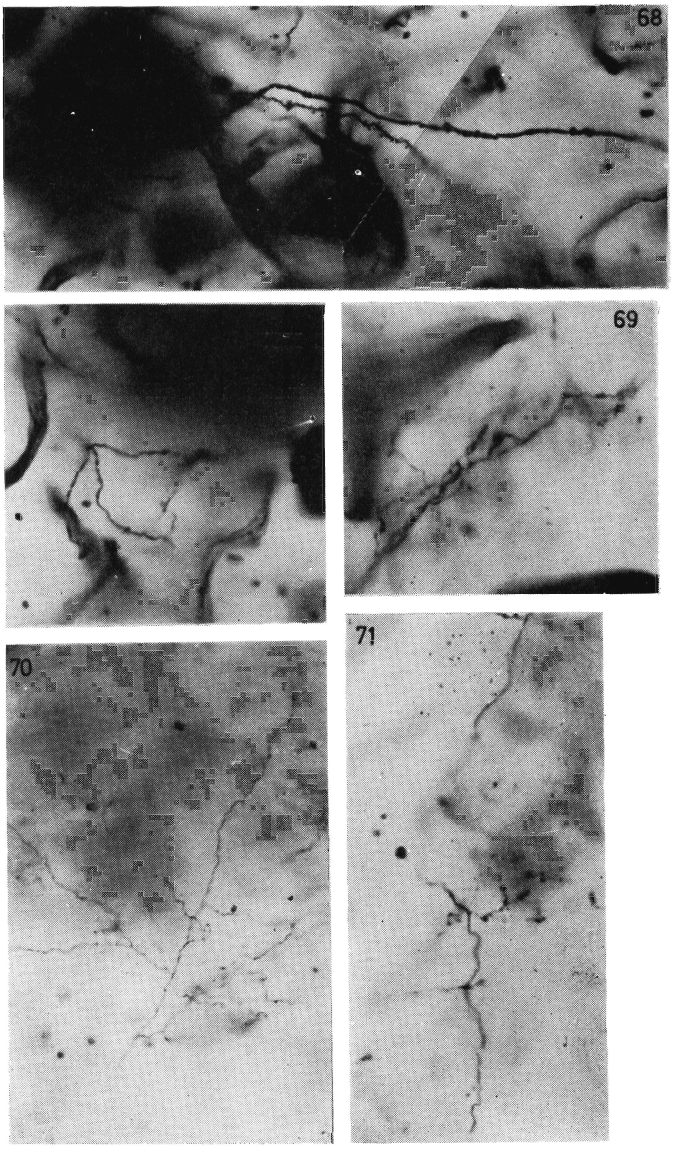

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PLATE XX

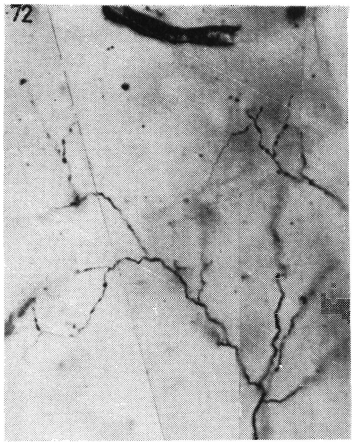
Patterns of preterminal arborizations of afferent fibers in the lateral nucleus

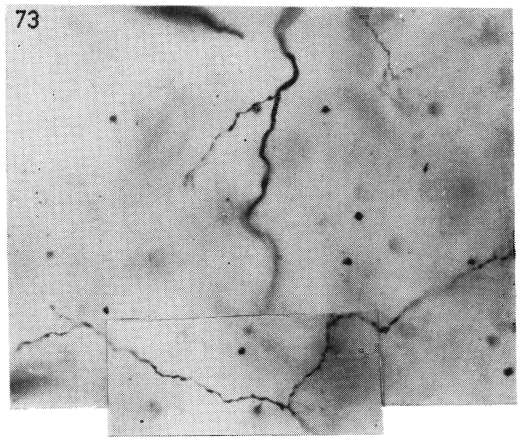
Explanation of Figures

72 Preterminal arborization of a medium thick afferent fiber which enters ventrally the lateral nucleus. × 250.

73 Thick and medium thick fibers which enter dorsally and ventrally the lateral nucleus. × 250.

74 Medium thick afferent fiber running in the medio-lateral direction. × 250.


72


73

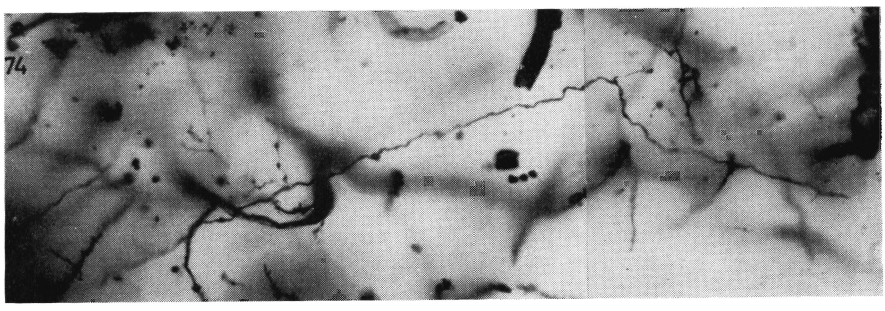

74

PLATE XXI

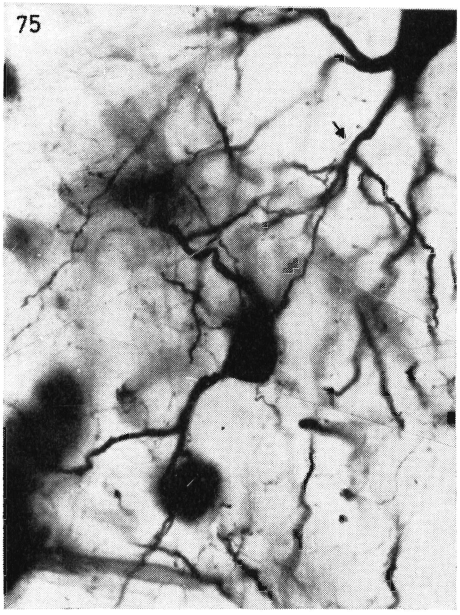
Terminal parts of axons in the lateral nucleus

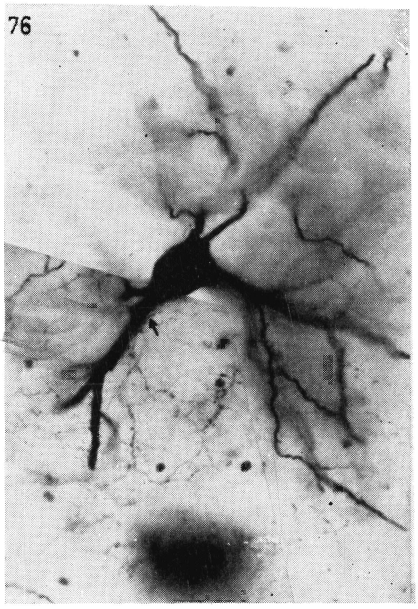
Explanation of Figures

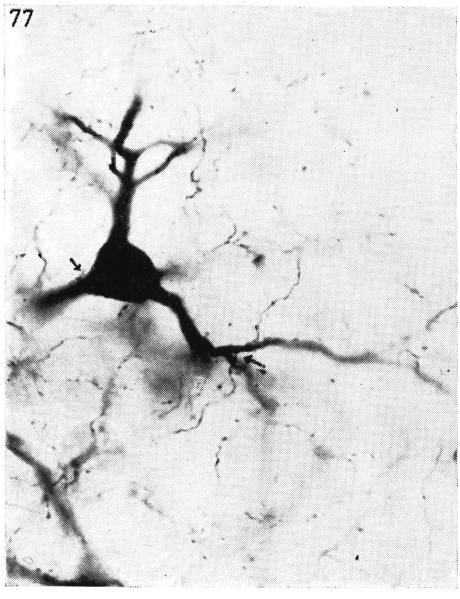
75 Arrow indicates the terminal part of thin axonal branch of the Golgi IIb type of neuron. × 250.

76, 77 The projective neurons in the network of the delicate neuropil (see arrows). × 250.

78 Dendrite of projective neuron in the network of neuropil. × 500.


75


76


77

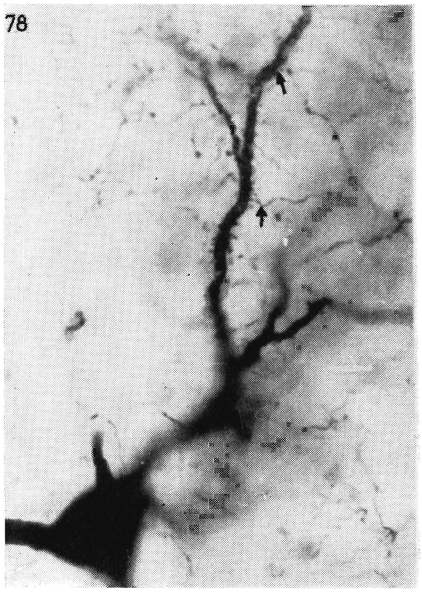

78

PLATE XXII

Neurons of the intercalate nuclei

Explanation of Figures

79 Small neuron with axon running dorsalward. Arrows indicate axonal collaterals. × 250.

80 Medium size neuron with polarly arranged dendrites. × 250.

81 The Golgi IIa type of neuron. Arrow indicates the axon ramification. × 250.

82 Group of small ovoid neurons with characteristic linear arrangement of dendrites. × 250.

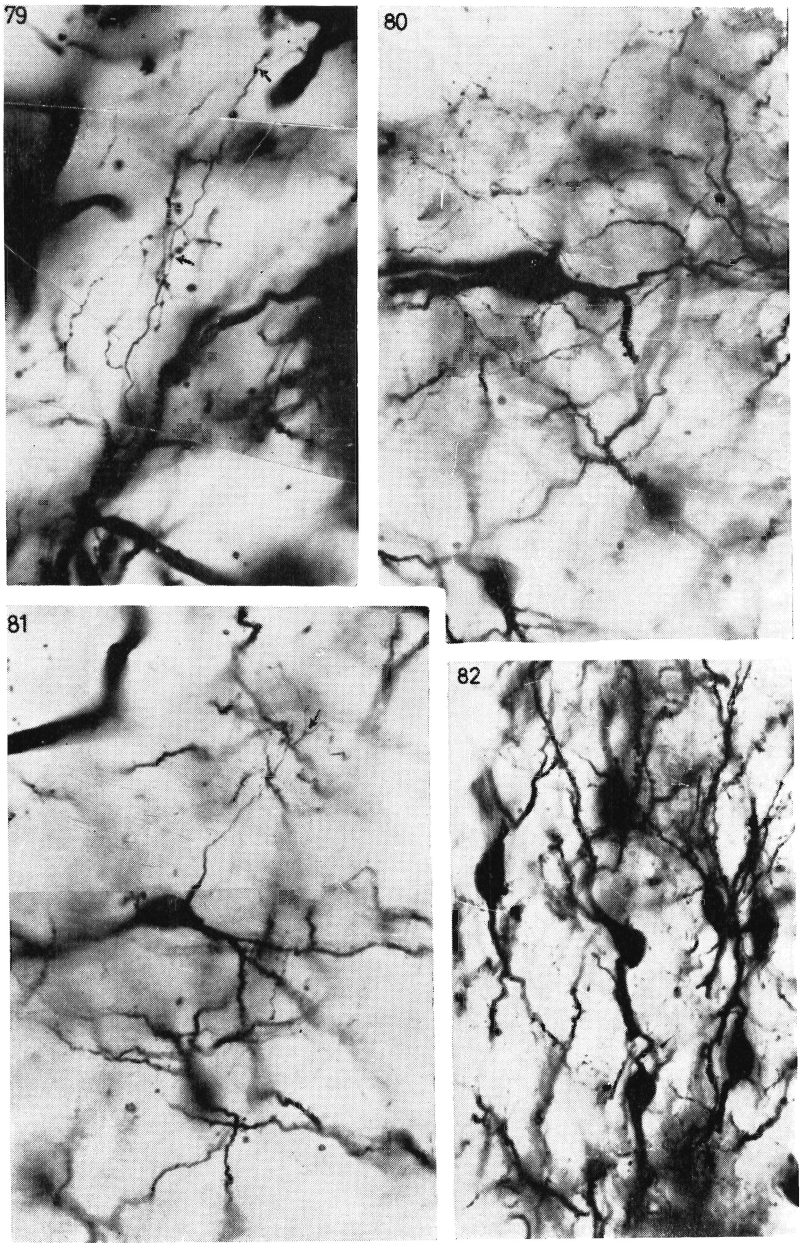
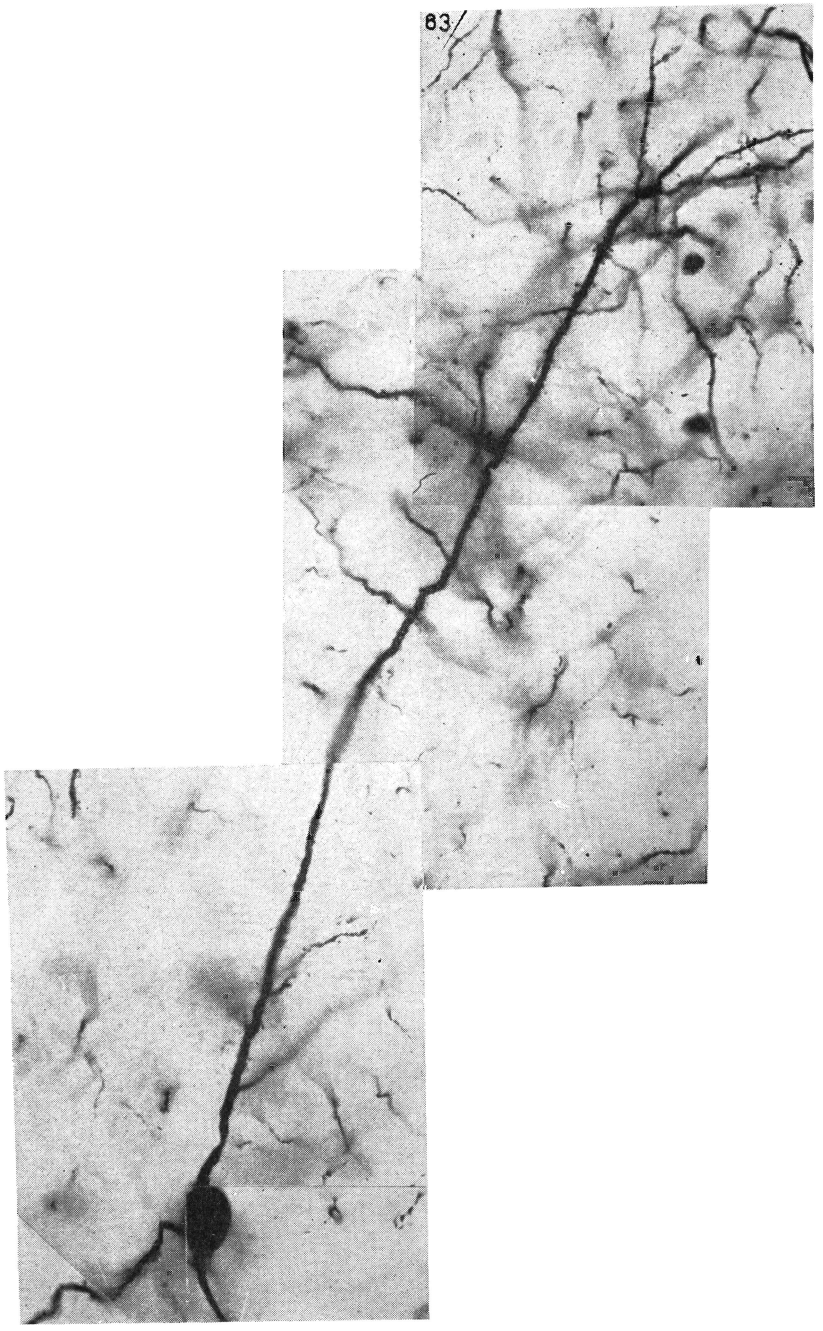

79
80
81
82

PLATE XXIII

Neuron of the intercalate nucleus

Explanation of Figures

83 Medium size neuron with very long (800 μ) dendrite. $\times$ 250.


63