STUDIES ON THE DIENCEPHALON OF CARNIVORA

PART I. THE NUCLEAR CONFIGURATION OF THE THALAMUS, EPITHALAMUS, AND HYPOTHALAMUS OF THE DOG AND CAT

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THIRTEEN PLATES (TWENTY-FOUR FIGURES)

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INTRODUCTION

Under the impetus of the recent interest in the diencephalon, much information has been accumulated and the anatomy of this portion of the nervous system is at least moderately well known for certain forms, especially for amphibians, reptiles, birds, and lower mammals. These data demonstrate that the previous analyses of the nuclear configuration of the diencephalon of higher mammals are not sufficiently accurate to form the basis of experimental work on the functions of this region. The present investigation has been undertaken in recognition of the need for a revision, in the light of recent studies on other vertebrates, of the analyses of the nuclear masses which compose the diencephalon of the dog. It forms a part of the general investigation of the diencephalon of vertebrates being conducted in the Laboratory of Anatomy of the University of Michigan. The dog was selected as the subject for investigation, because it is a commonly used laboratory animal and is an average representative of the Carnivora. As several series of serial sections of the brains of cats were available, they have been used as a check on the observations made on the dog brains, and marked differences between the two have been noted.

My sincerest thanks are due to Prof. G. Carl Huber, in whose department and under whose supervision this work was done, for his help and likewise for his preparation of the material on which this investigation was carried out. I should also like to take this opportunity of expressing my thanks to Dr. Elizabeth Crosby, in appreciation of the help, instruction, and advice she has given me.

MATERIAL AND METHODS

The material for this investigation consists of four series of serial sections, one each sagittal and transverse of the dog and of the cat, fixed in the alcohol-mercuric chloride-trichloracetic acid mixture (Huber, '27), embedded in paraffin, cut by the 'water-on-the-knife method,' and stained in toluidin blue for cytoarchitectonic study; and of three series of serial sections, one each sagittal and transverse of the dog and one transverse of the cat, prepared by a pyridin-silver method and similarly cut.

The outlines of the illustrations were made under a projection apparatus at a magnification of 17, the cells being filled in under microscopic control. The original drawings were reduced to one-third for printing, giving a final magnification of $5\frac{2}{3}$. The illustrations of the cells were made under a camera lucida at a magnification of 500 and reduced to one-third, to give a final magnification of 167.

LITERATURE

The literature on the mammalian diencephalon is not extensive, but is rather widely scattered through the past forty years. As several quite complete bibliographies have been published (Ganser, '82; Sachs, '09; Minkowski, '24; Gurdjian, '27, and Pines, '27), it will not be gone into in detail here, the relevant facts being discussed in connection with the particular nuclei. However, it is desirable to draw attention to the wide differences in the materials and methods used, which largely explain the diverging opinions regarding the topography of this region.

Several authors have described the normal topography of the diencephalon of different mammals, using either cytoarchitectonic or myeloarchitectonic methods, or a combination of these two. Among those using the first-mentioned method are Da Fano ('09), who described the dog, and Nissl ('89), who studied the rabbit. A paper by Friedemann ('12), on the diencephalon of Cercopithecus, with excellent plates, deserves special mention. Malone ('10) made an interesting study of the human diencephalon, using serial sections stained with Nissl's stain. He based his analysis of the nuclei on the cell types rather than on the grouping of the cells, using Jacobson's ('09) classification of the cells into motor and sensory. He extended this study to the cat ('12) and made a further classification of the cells ('13) into motor, sensory, and sympathetic. In 1914, this observer gave a more detailed account of the human hypothalamus. By use of myeloarchitectonic methods, Ganser ('82) studied the mole; Forel ('07), several small mammals and the human; Mann ('05), the human, and Vogt, C. ('09), the Cercopithecus. These studies were largely topographical, with some attempt to connect the fiber paths with the nuclei. Tsai ('25), on the opossum, Didelphis virginiana, and Le Gros Clark ('29), on Tupaia minor, put more emphasis on the fiber connections. Combination of the cytoarchitectonic and myeloarchitectonic methods have been used by d'Hollander ('13) on the rabbit, by Foix and Nicolesco ('25) in a monograph on the basal ganglia in the human, and by Pines ('27) in a topographical study of the diencephalon of Lemur catta. The two atlases of Winkler and Potter, one of the rabbit's brain ('11) and one of the cat's brain ('14), are also based on both cell and fiber material.

A few authors have studied the normal diencephalon by means of silver-impregnation material with very productive results, contributing especially to our knowledge of the fiber connections—and particularly of the non-myelinated fibers—of the thalamic nuclei. Ramón y Cajal ('11) did his monumental work mainly on the mouse, with references to the rabbit, cat, and human. More recently, Castaldi ('23, '24, and '26) described the mesencephalon, including the habenular and mammillary connections, of the rabbit. Gurdjian ('25, '26, and '27) gave a comprehensive description of the diencephalon and the telencephalon of the albino rat, using serial sections stained for cells, for myelinated fibers, and also different types of silver preparations. Among the comprehensive studies of submammalian thalamus, mention should be made of Herrick's study ('17) on the amphibian thalamus and the work of Huber and Crosby ('26 and '29) on the diencephalon of the alligator and of the bird, respectively.

A number of workers have studied degenerations following experimental and pathological lesions. Nissl ('13) studied the degeneration of the diencephalic nuclei in serial sections of the rabbit's brain, stained for cells, following extirpation of one cerebral hemisphere. Münzer and Wiener ('02) studied degenerations of the diencephalic nuclei and tracts, as shown in Weigert material, in a series of experiments on the rabbit in which different portions of the hemisphere were removed. They also gave a description of the normal configuration. von Monakow ('95), also using Weigert material, gave a description of the normal thalamus in the dog, cat, and human and followed this with a description of the cortical connections of the thalamic nuclei as demonstrated by von Gudden's method following localized lesions, experimental and pathological, in different parts of the cortex. Minkowski ('23 and '24), using the same classification of the thalamic nuclei as von Monakow, described the anatomical findings in a series of six experiments on the Macacus rhesus dealing with the Rolandic, frontal, parietal, and angular convolutions. He also very completely discussed the literature on this phase of the problem. Dejerine ('01) described the normal human diencephalon on the basis of Weigert material and gave an account of many of the fiber tracts and connections as shown in pathological specimens prepared by Weigert or Marchi technique. Sachs ('09), using monkeys (Macacus rhesus) and cats, described the Marchi degeneration found after localized lesions of the cortex and of the thalamic nuclei.

The thalamus has been studied from the phylogenetic point of view by a few authors. Forel ('07), in a short paper, discussed some of the major differences between several mammals. Sachs ('09) gave a topographical description of the thalamus of a series of mammals as shown by serial sections stained by Weigert technique. Ariëns Kappers ('21) discussed the phylogeny of the diencephalon from a more theoretical standpoint. Ingvar ('23), in an introductory paper, made an attempt to homologize the mammalian with the avian thalamus. More recently, Papez ('29) presented a brief description of the thalamus in his text-book of comparative neurology. There have also been several embryological studies, including the work of Bianchi ('09) and that of Castaldi ('23, '24, and '26), both on the thalamus of the rabbit.

Among the authors of more general texts, references may be made to the following: Meynert ('72) and van Gehuchten ('97), who based their discussion mainly on human material; Kölliker ('96), who studied the thalamus in several forms, but described it mainly from rabbit material; Barker ('99), who gave a general description from the standpoint of connections and function; Marburg ('04), who showed a series of cross-sections of the human diencephalon stained by the Weigert method in his atlas of the central nervous system; and Tilney and Riley ('21), who presented a general description of the form and functions of the human thalamus.

DESCRIPTION OF NUCLEAR GROUPS

In classifying the nuclei of the thalamus of the dog into groups, the description by Gurdjian ('27) of the albino rat has been followed more particularly, for the reason that he uses fiber connections as well as topographical relations as the basis of his classification. The terminology here employed also follows most closely that of Gurdjian ('27), with a few minor alterations and certain additions. The nomenclature of this observer is based on the current usage in several recent papers, with alterations where the terminology is not standardized and additions signifying as far as possible functional relations.

Anterior group of nuclei

The anterior group of nuclei (figs. 1 to 4, 15 to 17) occupies the tuberculum anterius, at the extreme rostral pole of the thalamus. It consists of the nucleus anterodorsalis, the nucleus anteroventralis, and the nucleus anteromedialis.

These may be logically grouped together, both on the basis of position and of fiber connections.

Nucleus anterodorsalis. This is the most dorsal of the anterior thalamic nuclei and lies as a moderately thick, well-demarcated layer of cells at the anterior dorsal and dorsomedial surface of the thalamus, forming, as it were, a cap in front of and above the anteroventral and anteromedial nuclei (fig. 16). The rostral pole extends up into the tuberculum anterius at the level of the posterior part of the anterior commissure, the extreme caudal pole extends to the level of the posterior part of the optic chiasm. Throughout its extent, to its caudal pole, it lies between the floor of the ventricle and the dorsal surfaces of the anteroventral and anteromedial nuclei, being separated from each of these by a clear fiber layer. At the caudal pole it is bounded ventrolaterally by the nucleus lateralis pars anterior and ventromedially by nucleus centralis lateralis. Its form and direction follow that of the ventricle above it, anteriorly being diagonal, and caudally being horizontal across the field.

A few sections caudal to the anterior commissure it extends ventromedially, between the nucleus parataenialis and the nucleus anteromedialis, to fuse with the nucleus commissuralis interanterodorsalis (figs. 1 and 2). This medial extension disappears at the level of the rostral pole of the nucleus medialis dorsalis. Throughout the remainder of its extent caudalward it is bounded medially by the nucleus parataenialis and laterally by the nucleus lateralis pars anterior.

There are occasional intercalated cells in the fibers running ventromedially from the nucleus which resemble those of the main mass. These may be small, medial extensions along commissural fibers. Passing caudally, the nucleus anterodorsalis becomes gradually smaller and the caudal boundary is formed by the nucleus lateralis pars anterior (figs. 4 and 5).

The cells of the nucleus lie close together, giving a dense appearance. The longitudinal axes of the cells are in relation to the fiber bundles running into and through the nucleus. Anteriorly, they are directed diagonally; caudally, they are horizontal in the medial and lateral portions and longitudinal in the central portion of the nucleus.

The cells are similar throughout the nucleus, being large in size, polygonal in form, and having numerous long processes (fig. 20, A). The cytoplasm appears rough and granular. The nuclei are large, round or oval in shape, and contain a distinct chromatin network and a single, deeply stained nucleolus.

Even in toluidin-blue preparations commissural fibers to the nucleus commissuralis interanterodorsalis are evident.

Nucleus anteroventralis. The anteroventral nucleus is a mass of cells occupying the ventrolateral portion of the tuberculum anterius. The rostral half of the nucleus is triangular in cross-section (figs. 1 to 3), while the caudal half varies from rhomboidal to oval (fig. 4). In sagittal sections the nucleus is pear-shaped (figs. 16 and 17), the small end being rostroventral and the large end caudodorsal. In its rostral half the nucleus is bounded dorsomedially by the nucleus anterodorsalis, ventrally by the nucleus anteromedialis, and laterally by the external medullary lamina which separates it from the nucleus reticularis thalami (figs. 1 and 2). In its caudal half the nucleus anterodorsalis remains as the dorsal boundary, the nucleus anteromedialis, situated more medially, form the ventromedial boundary, and the ventral nucleus, with its increased size laterally, constitutes the ventrolateral boundary (fig. 4). The nucleus lateralis, pars anterior, first appears at about the middle of the nucleus anteroventralis, increases rapidly in size caudally, and forms the laterocaudal boundary (fig. 4). At the extreme caudal pole the nucleus centralis lateralis replaces the nucleus anteromedialis, and thus forms the caudoventral and caudal boundaries (figs. 5 and 17). The nucleus anteroventralis is everywhere surrounded by a clear fiber zone, except in the region where it adjoins the nucleus anteromedialis. Here there is a moderate intermingling of the cells through a cell-poor fiber layer.

The nucleus anteroventralis can be divided quite distinctly into two parts: 1) a large-celled portion, forming the main mass of the nucleus; 2) a small-celled portion, forming the lateroventral corner of the nucleus and extending along the ventral margin to the medial border (figs. 1 and 2). This ventral band is occasionally interrupted by large cells. In the large-celled part the cells do not lie as closely together as do those of the nucleus anterodorsalis and have no definite arrangement with respect to fiber tracts. In the small-celled part the cells lie considerably closer together and are arranged in the course of diagonally running fibers.

The large cells (fig. 20, B) are the same size or slightly smaller than the cells of the nucleus anterodorsalis. They are somewhat more slender than the cells of that nucleus and are polygonal, triangular, and fusiform in shape. They have numerous long cytoplasmic processes. Their cytoplasm stains less deeply than does that of the cells of the nucleus anterodorsalis and is less granular. The nuclei, with their chromatin network and single nucleoli, are similar to those of this latter nucleus. The small cells (fig. 20, C) are considerably smaller than the large cells, sometimes only half the size. They are polygonal, with several long processes, and the cytoplasm appears paler and less granular. The nuclei are proportionately larger, but otherwise resemble the nuclei of the large cells.

Nucleus anteromedialis. The nucleus anteromedialis occupies the greater part of the ventromedial portion of the tuberculum anterius. The nuclei of the two sides, together with the nucleus commissuralis interanteromedialis, form a U-shaped structure, the nuclei anteromediales forming the arms, the bed nucleus of their commissure the base of the U (fig. 2). The nucleus anteromedialis lies medial and ventral to the nucleus anteroventralis and is slightly smaller than the latter. The medial part of the rostral boundary of the nucleus anteromedialis is formed by the anteroventral portion of the nucleus anteroventralis. In the angle between the midline structures and the nucleus anteromedialis lie the nucleus parataenialis and the medial portion of the nucleus anterodorsalis (figs. 1 and 2). More caudally, at a level just in front of the optic chiasm, these latter nuclei are replaced by the nucleus medialis dorsalis (figs. 3 and 4). At its rostral pole the nucleus anteromedialis is bounded ventrally by the external medullary lamina, which separates it from the nucleus reticularis thalami. Behind this it is separated ventrally from the nucleus ventralis by the internal medullary lamina, among the fibers of which are numerous, very small, intercalated cells (fig. 1). At about the level of the optic chiasm there is a transition zone between the ventromedial portion of the nucleus anteromedialis and the nucleus paracentralis as the latter extends out from the nucleus centralis medialis through the fibers of the internal medullary lamina (fig. 3). In proceeding caudally through the serial sections, the nucleus anteromedialis appears to be replaced gradually by the nucleus paracentralis medially and by the nucleus centralis lateralis laterally (figs. 4 and 5). The dorsal boundary is formed throughout by the nucleus anterodorsalis and the nucleus anteroventralis, and the lateral boundary by the nucleus anteroventralis.

The rostral pole of the nucleus medialis dorsalis is intimately associated with the medial portion of the nucleus anteromedialis (fig. 3), and no sharp line of demarcation can be drawn between them. In this region the cells of the nucleus anteromedialis are smaller and are more closely packed between fibers, resembling the cells of the anterior pole of the nucleus medialis dorsalis. At the caudal margins of the nucleus anteromedialis, where it is bounded by the nucleus paracentralis and the nucleus centralis lateralis, the line of demarcation is not distinct and again the cell structure becomes similar to that of the adjoining nuclei, the cells being larger and slightly more deeply stained than in the main portion of the nucleus (figs. 3 and 16).

At the extreme caudal pole a small process of the nucleus anteromedialis is separated from the nucleus medialis dorsalis by a group of large cells, apparently a dorsal extension of the nucleus centralis lateralis. In cross-section this process appears as an island of cells bounded laterally by the nucleus anteroventralis, and medially and ventrally by the nucleus centralis lateralis. This is apparently what Da Fano ('09) called the nucleus rotundus.

The cells in the main resemble those of the nucleus anteroventralis, being only slightly smaller (fig. 20, D). The same division into a large-celled and a small-celled part is seen rostrally, the large cells lying dorsomedially, the small ventrolaterally. The cells tend, however, to be oriented better with reference to fiber bundles.

von Monakow ('95), Münzer and Wiener ('02), Bianchi ('09), Ramón y Cajal ('11), Friedemann ('12), d'Hollander ('13), Winkler and Potter ('14, cat), Gurdjian ('27), Pines ('27), and Le Gros Clark ('29) divided the anterior group into three nuclei which are comparable to the above divisions. Marburg ('04), Vogt, C. ('09), Sachs ('09, '09 a), Winkler and Potter ('11, rabbit), Nissl ('13), Ingvar ('23), Tsai ('25), and others recognized a dorsal nucleus, the equivalent of the nucleus anterodorsalis, and a main nucleus, the equivalent of the nuclei anteroventralis and anteromedialis. A smaller number, among whom may be mentioned Dejerine ('01), Forel ('07), and Foix and Nicolesco ('25), described the group as a unit. Papez ('29) grouped his dorsal nucleus, comparable to the nucleus anterodorsalis of the dog, with his nucleus dorsomedialis, which is homologous with the nucleus parataenialis of the dog. Nissl ('13) and d'Hollander ('13) described a large-celled, dorsomedial, and a small-celled, ventrolateral, portion of the anteromedial-anteroventral group.

Medial group of nuclei

The medial group of the thalamic nuclei (figs. 1 to 9, 15 and 16) consists of the following: the nucleus parataenialis, the nucleus medialis dorsalis, the nucleus submedius, the nuclei of the habenulo-peduncular tract, the nucleus parafascicularis, the nucleus subparafascicularis, the nucleus paracentralis, and the nucleus centralis lateralis. The group extends the whole length of the thalamus, is dorsally bounded by the stria medullaris and the habenular complex, medially by the nuclear group of the midline, ventrally by the nucleus ventralis, and laterally by the nucleus lateralis.

Nucleus parataenialis. The nucleus parataenialis forms a band, triangular in cross-section, in the dorsomedial corner of the thalamus (figs. 1 to 3). Its rostral pole lies a little posterior to the rostral pole of the nucleus anterodorsalis. It extends caudally along the ventral surface of the stria medullaris, becoming gradually smaller until it ends at the level of the rostral pole of the habenular complex (figs. 4 to 6). At its rostral pole, and for a short distance caudally, it extends in a ventromedial direction to fuse with the bed nucleus of its commissure, the nucleus commissuralis interparataenialis (figs. 2 and 3). In this region it is bounded medially by the nucleus paraventricularis anterior and laterally and lateroventrally by the nucleus anterodorsalis and the nucleus commissuralis interanterodorsalis. Throughout the remainder of its extent it lies between the nucleus medialis dorsalis ventrally and the stria medullaris dorsally. Caudally, the nucleus parataenialis becomes more and more flattened out between the nucleus medialis dorsalis and the stria medullaris, until it is represented by a band only one to two cells thick and at its extreme caudal pole by a small group of cells just ventral to the lateral margin of the stria medullaris (fig. 6).

The cells at the anterior pole are arranged more or less vertically and appear to radiate out from the dorsomedial corner. More caudally, they lie between horizontal fibers ventral to the stria medullaris. The cells (fig. 21, A) resemble those of the nucleus anteroventralis, but are somewhat smaller. They are polygonal, with a large pale nucleus and relatively less cytoplasm. The cytoplasm contains diffuse, rather coarse, moderately deeply stained granulations. There are several cytoplasmic processes, which are not very long. The nuclei show a faintly stained, rather diffuse chromatin network—much of the chromatin being around the periphery—and a single, deeply stained nucleolus.

Nucleus medialis dorsalis. The nucleus medialis dorsalis is the largest of the medial group of nuclei and occupies most of the region lying between the internal medullary lamina and the midline group of nuclei. It is roughly egg-shaped in form. The nuclei of the habenulo-peduncular tract are included with it, forming a wedge-shaped segment in the dorsocaudal portion. The rostral pole (fig. 3) lies just anterior to the level of the optic chiasm and is separated by a thin fiber layer containing scattered, intercalated cells from the anterior group of nuclei and their commissural portions. The dorsal boundary is formed by the nucleus parataenialis to the level of the rostral pole of the habenular complex. Caudal to this point, the nuclei of the habenulo-peduncular tract and the capsule of the habenular complex form the dorsal boundary. The medial boundary at the rostral pole is formed by the nucleus parataenialis. Caudal to this the medial boundary consists of the periventricular system of fibers and the intercalated cells, which separate the nucleus medialis dorsalis from the midline group of nuclei, including the nucleus rhomboidalis and the nuclei paraventriculares anterior and posterior. Behind the nucleus rhomboidalis a few strands of cells of the nucleus medialis dorsalis extend along commissural fibers across the midline, constituting a commissural portion, which is very poorly developed in comparison with that found in rodents (figs. 5 and 6). The ventral boundary at the rostral pole is formed by a fusion with the medial portion of the nucleus anterior medialis. Behind this the ventral boundary is the internal medullary lamina and the nucleus paracentralis, which separate the nucleus medialis dorsalis from the nucleus submedius and the nucleus ventralis. In the caudal portions the internal medullary lamina becomes thin and less distinct, containing many intercalated cells, so that there is almost a fusion between the nucleus medialis dorsalis and the nucleus submedius (fig. 6). The lateral boundary of the rostral pole is formed by the nucleus anterior medialis, the line between the two nuclei being very indistinct. Caudal to this the lateral boundary consists of fibers of the internal medullary lamina throughout the rest of the extent of the nucleus medialis dorsalis. These fibers separate it from the nucleus centralis lateralis and, more caudally, from the nucleus lateralis pars intermedius and pars posterior. In the caudal half of its extent the boundary is not sharp, due to the presence of rather numerous, scattered cells in the internal medullary lamina. The caudal boundary of the nucleus medialis dorsalis is formed by the nuclei of the medial and lateral habenulo-peduncular tracts which extend down from the habenular complex with the fibers of the habenulo-peduncular system. The caudal pole of the nucleus medialis dorsalis extends in the form of a J around the ventral and lateral margins of these two nuclei (figs. 7 and 8) to the level where the habenulo-peduncular tract enters the nucleus parafascicularis. At this level the nucleus medialis dorsalis is separated from the nucleus parafascicularis by a thin layer of fibers.

The nucleus medialis dorsalis can be divided into two portions on the basis of cell form and arrangement, a main portion and a dorsomedial portion. In the main portion (fig. 21, B) the cells vary from small to medium size, are fusiform to triangular in shape, with several moderately long, branching, cytoplasmic processes. The cytoplasm contains fine, diffuse, fairly well-stained granulations. The nuclei are round to oval, small, pale, and clear, with a single, deeply staining nucleolus. In the rostrolateral margin of the nucleus are scattered, larger cells, similar to the large cells of the caudal pole of the nucleus anteromedialis.

The differentiation of the dorsomedial corner of the nucleus medialis dorsalis is first made out at the level of the caudal pole of the nucleus anteromedialis. Here this portion of the nucleus is continuous with the cells of the ventral portion of the nucleus parataenialis and at first appears to be more closely allied to the latter than to the nucleus medialis dorsalis. However, the cells (fig. 27, C) are smaller than the remaining cells of the nucleus parataenialis, take a reddish tinge in staining, similar to that of the cells of the nucleus medialis dorsalis, and have small, pale nuclei. They are fusiform in shape, small to medium in size, and are arranged as though spreading out along radiating fibers from the corner between the nucleus paraventricularis and nucleus parataenialis. The cells are different from those of the main part of the nucleus medialis dorsalis in that they are slightly larger on the average, a little more deeply stained, and are less densely arranged in the radiating manner described. A little more caudally, this area increases rapidly in size, spreading laterally and ventrally in a radial manner, following radiating fibers. Three groups of these fibers are apparent, one running ventrally, another into the center of the nucleus medialis dorsalis, where it also turns ventrally, and the third, laterally. At a level a little anterior to the anterior pole of the habenular complex, this group comprises about one-third of the area of the nucleus medialis dorsalis. Caudally, the group becomes continuous with the lateral and medial nuclei of the habenulo-peduncular tract.

Nucleus submedius, or medialis ventralis. Nucleus submedius consists of a cigar-shaped mass of cells lying in the angle formed by the ventral portion of the nucleus centralis medialis, medially, and the nucleus paracentralis, dorsally. The rostral pole is more or less continuous with the ventral extension of the nucleus anteromedialis at the level of the rostral pole of the nucleus paracentralis. Here it is bounded ventrally by the nucleus reuniens and ventrolaterally by the mammillo-thalamic tract, which separates it from the nucleus ventralis medialis (fig. 3). The dorsal boundary is formed throughout by the internal medullary lamina and the nucleus paracentralis. In its anterior third it is in close connection with the latter, but more caudally the two are separated by fibers of the internal medullary lamina. In its caudal third, where the nucleus paracentralis consists of smaller, more scattered cells, the nucleus submedius and the nucleus medialis dorsalis almost fuse (fig. 6). Caudal to the anterior pole, with the ventral shift of the nucleus reuniens, the medial boundary is formed by fibers and cells of the periventricular system, which separate it from the ventral portion of the nucleus centralis medialis. At places in the anterior third of the nucleus this midline area is very narrow and the cells thinned out, so that the nuclei submedii of the two sides almost touch in the midline. The lateral, ventrolateral, and ventral boundaries are formed at first by the mammillo-thalamic tract, which separates the nucleus submedius from the nucleus ventralis medialis (figs. 3 and 4). More caudally, as the mammillo-thalamic tract proceeds ventrally and enters the nucleus ventralis, the nucleus submedius is separated from the nucleus ventralis medialis by a narrow band of fibers, though at places the cells of the two nuclei lie in juxtaposition and can only be differentiated on the basis of their structure (figs. 5 and 6), the cells of the nucleus submedius being a little smaller and paler, with a more diffuse and less reticular arrangement. At the caudal pole, at a level a few sections caudal to the anterior pole of the habenular complex, there is a further intermingling of the cells of these two nuclei, and the nucleus ventralis medialis finally bounds the nucleus submedius caudally (fig. 7). In the caudal two-thirds the nucleus submedius is divided into a medial and a lateral portion by bundles of vertically running fibers (figs. 4 and 5). The two portions are similar in cell form and arrangement, and the only significance of this division seems to be the passage of bundles of fibers through the nucleus.

The cells of this nucleus (fig. 21, D) are arranged more or less concentrically inside of the surrounding fiber layers. On the whole, they are a little smaller and paler than those of the nucleus medialis dorsalis, but otherwise are entirely similar to them. In the toluidin-blue preparations they have the same pinkish or reddish tinge as do the cells of the nucleus medialis dorsalis, this being one of the differential points by which they can be distinguished from the cells of the nucleus ventralis medialis. Another differential characteristic is the smallness of their nuclei as compared with those of the cells of the nucleus ventralis medialis.

Nucleus tractus habenulo-peduncularis lateralis. This nucleus develops in connection with fibers of the lateral habenulo-peduncular tract which comes from the anterior three-quarters of the habenular complex. These fibers run, at first, ventrally and then turn caudally, gathering together into bundles and join with the posterior group of fibers to make a single fasciculus which penetrates the nucleus parafascicularis (fig. 15). The nucleus tractus habenulo-peduncularis lateralis thus forms a segment, like a wedge, extending ventrally from the habenular complex above into the nucleus medialis dorsalis in its caudal half (figs. 7 and 8). The anterior pole lies at the level of the anterior pole of the habenular complex, appearing as a few, scattered, large cells in conjunction with ventrally running habenulo-peduncular fibers among the cells of the dorsomedial portion of the nucleus medialis dorsalis, which at this level attains its largest dimensions. The dorsal boundary of the nucleus in question is formed throughout by the capsular fibers of the habenular complex. The medial boundary, at the anterior pole, is formed by the cells of the dorsomedial portion of the nucleus medialis dorsalis. More caudally, the nucleus tractus habenulo-peduncularis medialis lies medial to the nucleus of the lateral tract and separated from it by a medial band of fibers (fig. 8). At the caudal pole the latter nucleus is bounded medially by the central gray. The ventral boundary is formed, at first, by the main part of the nucleus medialis dorsalis, through which the habenulo-peduncular tract extends. There is no sharp line of demarcation between these nuclei, the differentiation being based on the character and arrangement of the cells. At the level of the anterior pole of the nucleus parafascicularis, the nucleus tractus habenulo-peduncularis lateralis extends ventrally entirely through the nucleus medialis dorsalis (fig. 8). The nucleus parafascicularis then forms its ventral and ventrocaudal boundaries. The boundary is marked by a thin fiber layer. Laterally, the nucleus tractus habenulo-peduncularis lateralis is bounded by the main portion and by the caudal pole of the nucleus medialis dorsalis. Caudally, the lateral boundary of the remaining dorsal portion of the former nucleus is completed by the pars posterior of the nucleus lateralis, as this swings medially to replace the caudal pole of the nucleus medialis dorsalis (fig. 9).

In cross-section the shape of the nucleus tractus habenulo-peduncularis lateralis varies from wedge-shaped to a half oval, according to the spread of the fibers of the habenulo-peduncular tract. The cells are arranged more or less irregularly, but apparently in conjunction with the ventrocaudally running fibers of the tract. The caudal group of fibers from the habenular complex forms a large bundle at the caudal pole of the nucleus tractus habenulo-peduncularis lateralis, and the cells of the latter are somewhat more dense rostrally and laterally to it, but apparently are not connected with this group of fibers as they are with the anterior lateral group.

The cells of the nucleus (fig. 21, F) vary in size from medium to moderately large and are rounded polygonal to triangular in shape, with several long, thick, clear, branching, cytoplasmic processes. The cytoplasm contains coarse, diffuse, well-stained granulations, which do not extend into the processes. The nuclei are large, round to oval in shape, pale and clear, with a single, deeply stained nucleolus. They resemble the cells of the nucleus parataenialis.

Nucleus tractus habenulo-peduncularis medialis. This nucleus (fig. 8) develops in connection with the medial group of fibers from the habenular complex, which apparently come from the medial portion of the habenula. It consists of a narrow band of cells along fibers which extend between the nucleus tractus habenulo-peduncularis lateralis and the periventricular system in a curve which is convex toward the midline. The anterior pole lies as scattered cells along these fibers a few sections caudal to the anterior pole of the nucleus of the lateral tract. Rostrally, it is bounded by the cells of the dorsomedial corner of the nucleus medialis dorsalis, with which it fuses, and so extends dorsally to the capsule of the habenular complex. It here reaches its largest dimensions. Medially, it is bounded throughout by fibers of the periventricular system, with their very small, scattered, intercalated cells, which separate it from the nucleus paraventricularis posterior. Ventrally, the fibers along which the nucleus extends swing away from the midline and run into the ventral portion of the main part of the nucleus medialis dorsalis. At places it seems to fuse with the ventromedial portion of the nucleus medialis dorsalis, but for the most part the two nuclei are separated by a fiber layer. Caudal to the nucleus medialis dorsalis the ventral portion is separated by a distinct fiber layer from the nucleus parafascicularis. Laterally, the nucleus is bounded throughout by fibers which at first separate it from the few remaining cells of the dorsomedial corner of the nucleus medialis dorsalis, then from the nucleus tractus habenulo-peduncularis lateralis. The caudal boundary is formed by the periventricular system dorsally and by the nucleus parafascicularis ventrally.

The cells of the nucleus tractus habenulo-peduncularis medialis are lined up along the fiber bundles, as indicated above, and are small, fusiform, elongated, with moderately deeply stained, finely granular cytoplasm and long, clear processes. The nuclei are long, oval, pale, and clear, with a single deeply stained nucleolus. The cells resemble those of the nucleus paraventricularis in many ways, and from their form and position belong to the same general system.

Nucleus parafascicularis. This nucleus is the most caudal of the medial group of nuclei. It is triangular in form in sagittal sections (figs. 15 and 16) and lies caudoventral to the nucleus tractus habenulo-peduncularis lateralis, its base resting on the nucleus commissuralis interventralis and extending for a short distance caudal to the latter. The posterior surface is almost flat and vertical and is bounded by a thin layer of fibers separating it from the nuclei of the posterior commissure group. The anterior pole of the nucleus parafascicularis appears in the cross-sections as a band of small intercalated cells in the internal medullary lamina a short distance caudal to the termination of the nucleus paracentralis and extends from the lateral margin of the caudal pole of the nucleus centralis medialis laterally to where the fibers of the internal medullary lamina turn dorsally (fig. 8).

There is a question of fusion of the nuclei of the two sides across the midline for a short distance ventral to the caudal pole of the nucleus centralis medialis. In the caudal planes the periventricular system of cells and fibers separates it from the midline. It is separated ventrally from the nucleus commissuralis interventralis by a thin band of fibers and caudal to the termination of the latter it is bounded ventrally by the nucleus subparafascicularis, which lies in the external medullary lamina and separates the nucleus parafascicularis from the hypothalamus. In the caudal planes it extends dorsally almost to the fibers surrounding the habenular complex, but a small portion of the nucleus tractus habenulo-peduncularis lateralis always remains dorsal to it (fig. 9). The bundles of fibers of the habenulo-peduncular tract pierce it diagonally and there is a condensation of cells around them, but there is no evidence that the fibers terminate in this nucleus (figs. 9 and 15). The cells around the tract are larger and more dense than those in the lateral portion of the nucleus, where they lie irregularly scattered among the anterior fibers of the posterior commissural system. Laterally, the nucleus is bounded throughout by the dorsally running fibers of the caudal portion of the internal medullary lamina.

The arrangement of the cells depends on the direction of the fibers of the region. In the anterior margin they lie horizontally in the fibers of the internal medullary lamina. Around the habenulo-peduncular tract they are lined up in the direction of the fibers of the latter. In the lateral portion they are scattered through the fibers of the commissural system. The cells (fig. 21, G) are small, with diffusely granular, moderately deeply staining cytoplasm. They are fusiform in shape and have one to two moderately long, thin processes. The nuclei are relatively large, oval, with a coarse chromatin network and a single deeply stained nucleolus.

Nucleus subparafascicularis. This nucleus consists of a layer of small, intercalated cells in the external medullary lamina behind the nucleus commissuralis interventralis. The dorsal boundary is formed at first by the nucleus parafascicularis and caudal to that by the nuclear groups associated with the posterior commissure. At its anterior pole it is medially bounded by the periventricular system of fibers. In descending, the habenulo-peduncular tract forms its medial boundary and the nucleus subparafascicularis shifts laterally (fig. 9). Caudal to the tract the medial boundary is formed by the gray in association with the commissura posterior. The ventral boundary is formed throughout by a thin layer of fibers of the external medullary lamina which separates it from the hypothalamus. Laterally, it is at first bounded by the intercalated cells of the caudal pole of the external portion of the nucleus ventralis. It forms the caudal boundary of this portion of the ventral nucleus and extends laterally to reach the medial portion of the capsule of the nucleus geniculatus medialis (fig. 9). Caudally, it is continuous with scattered cells in diagonally running fibers ventrolateral to the nuclear gray of the commissura posterior (fig. 10).

The cells are arranged horizontally, lined up in fibers of the external medullary lamina. They are small and fusiform in shape, with short processes. The cytoplasm is pale, almost shadowy. The nuclei are small, oval, and pale, with a single nucleolus.

Nucleus paracentralis. This nucleus consists of a group of cells in the internal medullary lamina extending out from the dorsolateral corner of the nucleus centralis medialis and connecting the latter with the ventromedial corner of the nucleus centralis lateralis. The anterior pole fuses rostrally with the caudal margin of the ventral extension of the nucleus anteromedialis (fig. 3). In this region the cells extend ventrally for a short distance along the fibers of the internal thalamic peduncle. This ventral extension fuses a little farther caudally with the anterior pole of the nucleus submedius and becomes replaced by it. The dorsal boundary of the rostral pole is formed by the nucleus commissuralis interanteromedialis. Caudal to that, the dorsal boundary is formed by nucleus medialis dorsalis throughout the remaining extent of the paracentral nucleus (figs. 4 to 7). The nucleus reuniens and the periventricular gray extend between the anterior pole of the nucleus paracentralis and the nucleus centralis medialis for a short distance, but throughout the rest of its extent the nucleus paracentralis is continuous medially with the nucleus centralis medialis. Laterally, the former nucleus is bounded at first by the nucleus anteromedialis and the nucleus ventralis anterior, extending as a wedge between them (fig. 3). More caudally, with the development of the nucleus centralis lateralis, it is continuous with the ventromedial portion of the latter, and this relationship is maintained throughout the remainder of its extent. Ventrally, it is bounded by the nucleus ventralis anterior, from which it is separated by a rather broad fiber layer. More caudally, the nucleus submedius lies in the angle between the nucleus centralis medialis and the nucleus paracentralis, at places almost fusing with them and forming the medial portion of the ventral boundary of the latter (figs. 3 to 6). The lateral portion of the ventral boundary is formed by the nucleus ventralis pars medialis and pars arcuata, which also form the whole of the ventral boundary for a short distance caudal to the termination of the nucleus submedius (fig. 7). Caudally, it is bounded by the anterior pole of the nucleus parafascicularis above and by the nucleus commissuralis interventralis below (fig. 8).

In the portion of the nucleus paracentralis rostral to the nucleus centralis lateralis the cells are arranged in a moderately broad band, lined up in horizontally running fibers, and divided into a coarse, irregular reticulum by diagonally running fibers. The cells, for the most part, are intermediate in size between those of the nucleus centralis medialis and the nucleus centralis lateralis, and are entirely similar to the latter in form and structure. Caudal to the anterior pole of the nucleus centralis lateralis, the cells gradually become smaller and the band narrower. The larger cells appear mainly in a narrow band between the more ventral fibers of the internal medullary lamina, while a band of varying width consisting of small intercalated cells is scattered in the dorsal fibers and mixed with the cells of the nucleus medialis dorsalis (figs. 4 and 5). Caudal to the level of the main portion of the nucleus centralis lateralis, the large cells are found only where the nucleus paracentralis fuses with the nucleus centralis medialis, the remainder consisting of intercalated cells among the fibers of the internal medullary lamina (figs. 6 and 7). However, these intercalated, small cells stain more deeply than the cells of the nucleus medialis dorsalis, maintaining the tint of the typical cells of the nucleus centralis.

The cells of the anterior pole are moderately small, rhomboidal in shape, with short cytoplasmic processes. The cytoplasm contains deep-staining granulations in blotchy clumps, the nuclei are of moderate size, oval to round in shape, with a diffuse, rather coarse chromatin network and a single deeply staining nucleolus. The typical cells of the nucleus paracentralis are lined up in the horizontally running fibers of the internal medullary lamina. They are larger than the more anterior cells, are polyhedral to triangular or fusiform in shape, with several short processes. There is a moderately large amount of cytoplasm, containing deeply stained granulations in clumps. The nuclei are large and pale, with a diffuse, pale chromatin network and a single, rather large, deeply stained nucleolus. As the cells become smaller more caudally they are fusiform in shape, with relatively longer processes, but the structure of the cytoplasm and the nuclei remains the same.

Nucleus centralis lateralis. This nucleus is a crescent-shaped mass of cells among the vertically running, lateral fibers of the internal medullary lamina, separating the medial from the lateral group of nuclei. Its rostral pole appears as a lateral extension of the nucleus paracentralis (fig. 4) at the ventral margin of the caudal pole of the nucleus anteromedialis and separated from the latter by a capsular fiber layer, though there is some mixing of the cells through the fibers. The main portion of the nucleus lies directly caudal to the nucleus anteromedialis, separated from it as noted above (figs. 16 and 17). The cells of the nucleus anteromedialis adjoining the nucleus centralis lateralis are larger than the more anterior cells of the nucleus anteromedialis, but can be easily differentiated from those of the nucleus centralis lateralis by their paler cytoplasm and longer processes. The dorsal boundary is formed at first by the caudal pole of the nucleus anteromedialis (fig. 4), then by the caudal pole of the nucleus anterodorsalis, and finally by the stratum zonale (fig. 5). Caudal to this, the pars intermedia of the lateral nucleus comes to lie dorsally (fig. 6), though at places groups of cells belonging to the central nuclear system can be seen extending to the dorsal surface of the thalamus among the fibers of the internal medullary lumina. Medially, it fuses at its ventromedial corner with the nucleus paracentralis throughout the extent of the latter and, more caudally, borders on the nucleus parafascicularis (fig. 8). The nucleus medialis dorsalis lies in the cup thus made by the nuclei of the internal medullary lamina and, for the most part, is separated from them by fibers of the same, containing scattered intercalated cells, though at places, especially anteriorly at the region of the caudal pole of the nucleus anterior medialis, it is not always possible to draw a line between the nucleus medialis dorsalis and the nucleus centralis lateralis, due to the presence of large cells in the lateral margin of the former group (fig. 4). Also at the caudal pole, where the cells of the nucleus centralis lateralis are considerably smaller, it fuses with the nucleus medialis dorsalis to form the lateral boundary of the nucleus tractus habenulo-peduncularis lateralis (figs. 7 and 8). The lateral boundary of the anterior pole of the nucleus centralis lateralis is formed by the nucleus lateralis, pars anterior, and by the nucleus ventralis, pars anterior, with which latter the nucleus centralis lateralis fuses along fibers running into the internal medullary lamina from the lateral thalamic radiations (fig. 4). Caudal to this the lateral boundary is formed by the nucleus lateralis, pars intermedia (fig. 5), and more caudally still, by the nucleus lateralis, pars posterior (figs. 6 and 7) The nucleus centralis lateralis adjoins, but does not mix with, the cells of the anterior pole of the pars intermedius, and more caudally the two are separated by fibers of the internal medullary lamina (fig. 5). The ventral boundary is formed rostrally by the nucleus ventralis, pars arcuata. More caudally, however, medioventral projections from the pars intermedia and the pars posterior of the nucleus lateralis extend between it and the ventral nucleus (figs. 5, 6, and 7). Caudally, the nucleus centralis lateralis becomes continuous with intercalated cells in the internal medullary lamina which fuse with the caudal pole of the nucleus medialis dorsalis (fig. 8).

At the anterior ventral pole the cells are elongated between the laterally running fibers of the internal medullary lamina and extend laterally to fuse with the cells of the nucleus ventralis anterior. In the main portion of the nucleus, just caudal to the nucleus anterior medialis, the cells are irregularly arranged in the form of a thick crescent in cross-section. They are among the largest cells of the thalamus, being slightly smaller than the largest cells of the nucleus ventralis. The cells (fig. 21, E) are polyhedral, with a large amount of cytoplasm containing coarse, deeply stained granulations in clumps. They have several short, fine processes. The nuclei are large and pale, with a diffuse, faint, chromatin network and a single, large, deeply stained nucleolus. A little more caudally, the group becomes less homogeneous, the larger cells appearing more in the center, with a lateral border of smaller cells continuous with the cells of the nucleus paracentralis. Caudal to this, at the level of the posterior half of the pars intermedia of the lateral nucleus, the nucleus centralis lateralis consists of a large, crescentic area with scattered groups of large cells and irregular bands of smaller cells in the fibers of the internal medullary lamina. The size of the cells gradually decreases caudally, though they continue to stain more deeply than the other cells of the region. More caudally, at the level of the anterior pole of the pars posterior of the lateral nucleus, the nucleus centralis lateralis becomes much narrower and consists of cells among the fibers of the internal medullary lamina, varying in size from small intercalated cells to cells of medium size, with a few irregular patches of somewhat larger cells. From here to its caudal pole, at the level of the anterior portion of the nucleus parafascicularis, the nucleus centralis lateralis becomes less and less definite, consisting of intercalated cells in the internal medullary lamina which fuse with the nucleus medialis dorsalis. It also contains several dense groups or rosettes of slightly larger cells similar to the groups seen in the same sectional levels in the pars posterior of the lateral nucleus (fig. 8). Some of these groups lie half in one and half in the other nucleus.

A nucleus homologous with the nucleus parataenialis has been described for a number of mammalian forms, including insectivores (Le Gros Clark, '29), rodents (Nissl, '13; d'Hollander, '13; Gurdjian, '27), carnivores (Papez, '29), and primates (Vogt, '09; Friedemann, '12). As Le Gros Clark recognized two distinct parts to this nucleus in insectivores and Friedemann classed it with the nucleus paraventricularis (see below), the various descriptions indicate that this nucleus decreases in size in the ascending mammalian scale. In the human it was included by Kölliker ('96) in his nucleus intermedius, figures 669 and 670, and by Malone ('10) in his nucleus reuniens. Ramón y Cajal ('11) included this nucleus in his noyau supérieur du raphé. Under the name of nucleus arcuatus dorsalis Münzer and Wiener ('02, figs. 2 and 3) and Bianchi ('09, figs. 52 to 54) pictured this nucleus, but in their description and in their other figures the term includes other nuclear groups. Winkler and Potter ('11 and '14) designated this nucleus in neither the rabbit nor cat. These authors, as Dejerine ('01), von Monakow ('95), Sachs ('09), and others, apparently included it with the nucleus medialis dorsalis.

The nucleus medialis dorsalis is the classically described medial nucleus of the thalamus (medialer Hauptkern, med a, of von Monakow, '95). The differences in the various descriptions in the literature are largely concerned with establishment of the exact boundaries and are of minor importance for the present discussion. Certain authors have divided it into two parts. Thus Winkler and Potter ('14), in cat, figure a medialis b, a lateral part, and medialis bI, a small-celled, medial part. Vogt ('09), followed by Pines ('27) on the basis of fiber material, described a classical medial nucleus and a fibrous medial portion. Friedemann ('12), in addition to the typical medial nucleus, differentiated a large-celled medial part and a dorsal zonal portion, the latter possibly being homologous with the large-celled, dorsomedial portion of the nucleus in the dog.

The nucleus tractus habenulo-peduncularis lateralis and the nucleus tractus habenulo-peduncularis medialis have not previously been differentiated in mammals. The nucleus of the tract of Meynert shown by Winkler and Potter ('11 and '14) is homologous with the nucleus parafascicularis of other observers. The nuclei here described are more comparable to the nucleus of the habenulo-peduncular tract of birds (Huber and Crosby, '29) and may be homologous.

The nucleus parafascicularis has been recognized by most of the later workers. It will not be further discussed here.

The nucleus paracentralis and nucleus centralis lateralis, together with the nucleus centralis medialis (see below), are associated with the internal medullary lamina, which is a highly important component of the medial commissural system. Several authors, von Monakow for dog and cat ('95), Ramón y Cajal ('11), d'Hollander ('13), Winkler and Potter ('14), Gurdjian ('27), Le Gros Clark ('29), dealing with lower mammals, in which the medial commissural nuclei are well developed, have recognized a fairly well-demarcated nucleus of the internal medullary lamina homologous with the nucleus paracentralis described here. In primates Vogt ('09), Friedemann ('12), and Pines ('27) describe scattered cells forming a paralamellare nucleus. In the literature concerned with fiber connections and in that concerned with higher mammals there has been a most unfortunate confusion between the nucleus paracentralis and the centre médian nucleus of Luys. This confusion is due in part to the use of Weigert preparations in which differences in the cell structure between the paralamellare nuclei and the ventral nuclei cannot be determined, so that in several papers it is a matter of conjecture, even with the help of the illustrations, as to which nucleus the author is referring. Thus by some the nucleus medialis b of von Monakow and by others an area ventrolateral to that, apparently included in the nucleus ventralis b of von Monakow, have been regarded as the centre médian of Luys.

Several observers (von Monakow, '95; Bianchi, '09; Da Fano, '09; Nissl, '13; d'Hollander, '13; Winkler and Potter, '14), working on rabbit, dog, and cat, have described a large, well-differentiated nucleus, homologous with the nucleus centralis lateralis (the nucleus medialis c of von Monakow, the nucleus magnocellularis of other authors) in the lateral part of the internal medullary lamina. This nucleus is present, but relatively smaller, in primates (Friedemann, '12; Pines, '27), but has not been described by those working with Weigert material in these forms (Vogt, '09). Neither has it been described for human. It is apparently not differentiable from the nucleus paracentralis in the mouse and rat (Ramón y Cajal, '11; Gurdjian, '27).

Nuclei of the midline

This group (figs. 2 to 8) consists of a number of nuclei occupying the midline between the two thalami. In the dog, with the exception of the nucleus centralis, these nuclei are small and poorly defined so that by most authors they are included in the blanket terms of 'central gray' and 'commissura media.' The nuclei of this group may be divided into two types: the first commissural, the other associated with the periventricular system of fibers. The first type consists of the bed nuclei of the commissures between certain of the thalamic nuclei of the two sides and comprises the following structures: the nucleus commissuralis interparataenialis, nucleus commissuralis interanterodorsalis, nucleus commissuralis interanteromedialis, nucleus rhomboidalis, nucleus centralis medialis, and nucleus commissuralis interventralis, in the order in which they lie from above downward and from in front caudally. The nucleus rhomboidalis is probably also associated with the periventricular system, as are also the nucleus paraventricularis anterior, the nucleus paraventricularis posterior, and the nucleus reuniens.

Nucleus commissuralis interparataenialis. This is the most rostral and dorsal of the group of commissural nuclei. It is very small and is differentiated in cell preparations with difficulty. It is bounded rostrally and dorsally by fibers of the periventricular system. Caudally and ventrally, it is continuous with the nucleus commissuralis interanterodorsalis. Laterally, it extends out toward the ventral extension of the nucleus parataenialis (fig. 3), but does not definitely fuse with the latter, due to the presence of vertically running fibers of the periventricular system and the ventral extensions of the nucleus paraventricularis. Most of the cells are arranged transversely, some of them vertically, due to the vertical, periventricular fibers. The cells are small and poorly differentiated in type. They are fusiform in shape, with moderately long, fine processes. The cytoplasm is diffusely granular and rather palely stained. The nuclei are large relative to the size of the cell and are pale, with single, small nucleoli.

Nucleus commissuralis interanterodorsalis. This nucleus forms a small group of cells roughly in the form of a bow, the arms extending laterally and rostrally where they fuse with the ventromedial extensions of the nucleus anterodorsalis (fig. 1). Ventrally and caudally, the arms are continuous with the lateral extensions of the nucleus commissuralis interanteromedialis (fig. 2). The central portion fuses rostrally and dorsally with the nucleus interparataenialis. The lateral arms are partially separated from the midline portion by fibers of the periventricular system. The nucleus is nowhere very definitely demarcated from the adjoining nuclei of the commissural group. It lies in the anterior portion of the midline group, in the same cross-sectional levels as the anterior pole of the ventral nucleus, just behind the most medial extension of the nucleus anterodorsalis. The cells are arranged transversely and are similar to those of the nucleus interparataenialis.

Nucleus commissuralis interanteromedialis. This is the third of the series of midline, commissural nuclei in the anterior portion of the thalamus. It consists of transversely lying cells connecting the nuclei anteromediales of the two sides. In the midline it is continuous rostrally and dorsally with the nucleus commissuralis interoanterodorsalis (figs. 1 to 3); ventrally, it fuses with the nucleus centralis and, caudally and caudoventrally, with the nucleus rhomboidalis (figs. 2 and 3). It is rather well differentiated from the two latter by its cell type. The lateral extensions are continuous dorsorostrally with the lateral extensions of the nucleus commissuralis interanterodorsalis. Caudal to the termination of the latter, the lateral extensions lie between the anterior pole of the nucleus medialis dorsalis and the anterior pole of the nucleus paracentralis and fuse laterally with the nucleus anteromedialis. The cells of the nucleus commissuralis interanteromedialis are arranged transversely and are of the same relatively undifferentiated character as are those of the nuclei commissuralis interparataenialis and interanterodorsalis.

Nucleus commissuralis intermedialisdorsalis. There is no definite nucleus in the dog corresponding to the bed nucleus of the commissura intermedialis dorsalis of rodents. However, among the cells of the periventricular system, lying dorsal to the nucleus rhomboidalis and, more caudally, dorsal to the nucleus centralis medialis, there are occasional small groups of commissural fibers, along which the cells are arranged more or less transversely (figs. 5 and 6). These scattered groups are probably the phylogenetic rudiments of the rodent nucleus. Most of them occur for a short distance posterior to the caudal pole of nucleus rhomboidalis.

Nucleus rhomboidalis. This is the fourth nucleus of the midline commissural group of nuclei. Its rostral pole lies just caudal to the rostral pole of the nucleus centralis medialis and between the latter and the nucleus commissuralis interanteromedialis. Rostrally (fig. 3), it is continuous with the nucleus commissuralis interanteromedialis and dorsally it is bounded at first by this same nucleus and more caudally by the periventricular system. Laterally (figs. 3 and 4), it is separated from the nucleus medialis dorsalis by fibers and intercalated cells of the periventricular system. Ventrally, it is bounded by and fuses with the dorsal surface of the nucleus centralis medialis. In cross-section it is rhomboidal in shape, the ventral surface being broader than the dorsal. It extends caudalward to the level of the caudal pole of the nucleus anteromedialis, where it becomes continuous with the periventricular system behind it (fig. 4).

At the rostral pole the cells are grouped without respect to fiber bundles and are a little less densely arranged than those of the nucleus centralis medialis. More caudally, the cells become smaller, more scattered, and lined up by vertically running fibers. The cells are less dense in the midline than farther lateralward, so that the nucleus appears to consist of two groups, one on each side of the midline. The cells are smaller than those of the nucleus centralis medialis, but are otherwise similar. Dorsally and caudally, they pass through transitional forms to cells of the periventricular system.

Nucleus centralis medialis. The nucleus centralis medialis is the fifth in the series of midline commissural nuclei. Its anterior pole lies at the level of the anterior pole of the paracentral nuclei, but is separated from them by periventricular fibers (fig. 2). A little farther caudally it fuses with the paracentral nuclei (fig. 3) and continues caudalward between the internal medullary laminae of the two sides to the level of the posterior third of the habenular complex (figs. 3 to 8). Here it becomes continuous through a transition zone with the periventricular system, which system also bounds it rostrally. The nucleus centralis medialis may be divided into a dorsal and a ventral portion, the former being commissural in nature, the latter forming a midline structure, at each side of which lie the nuclei submedius and reuniens (figs. 3 to 6). At the anterior pole the dorsal boundary is formed by the nucleus commissuralis interanteromedialis. Behind that it is formed by the nucleus rhomboidalis and then by a fusion of the nucleus centralis medialis with the periventricular system and with the nucleus paraventricularis posterior. The ventral boundary is formed by the periventricular system of fibers which occupies the midline ventral to the nucleus and swings lateralward around it to separate it from the nucleus submedius on each side. Rostrally, the ventral portion is large and is bounded on each side by the nucleus reuniens, the two being rather intimately associated. It becomes smaller caudally and changes in size and shape from section to section, at times being fused with the dorsal portion, at other places more or less separated from the dorsal portion by what appear to be commissural fibers between the two nuclei submedii. The ventral portion does not extend as far caudalward as the dorsal portion, being bounded caudally by the nucleus commissuralis interventralis (fig. 8). In the cat the nucleus reuniens is a much larger structure than in the dog and there is no definite ventral portion to the nucleus centralis medialis. In the sagittal sections the nucleus centralis medialis is seen to be broken up into numerous groups of cells by large bundles of transversely running fibers which apparently come from or enter into the internal medullary laminae.

The cells throughout the nucleus are of the same type, though larger rostrally than caudally. At the rostral end the cells are very densely grouped around the midline, the marginal cells of the group being smaller and lined up between the surrounding fibers of the periventricular system. Passing caudally, the cells become smaller and form a flattened Y, the two arms of which connect the paracentral nuclei. The cells forming the arms of the Y lie more or less transversely; those forming the base are lined up between vertically running fibers. Caudal to the point of disappearance of the ventral portion, the cells are smaller and paler and finally become indistinguishable from the cells of the periventricular system. Throughout, the marginal cells of the group pass through transitional forms into cells of the surrounding central gray. The typical cells of the nucleus centralis medialis are medium-sized, rounded polygonal to triangular in shape, with blotchy, granular, deeply staining cytoplasm and several moderately long cytoplasmic processes. The nuclei are small, round or oval in shape, with a coarse chromatin network and a single, deeply staining nucleolus. Caudally, the cells are considerably paler, as well as smaller, in general becoming less and less differentiated and more like the undifferentiated, intercalated cells associated with fibers.

Nucleus commissuralis interventralis. This nucleus will be considered as *nucleus ventralis pars commissuralis* (p. 61).

Nucleus paraventricularis anterior. The nucleus paraventricularis anterior lies in the periventricular system of fibers and appears as though it were a condensation and differentiation of the small, intercalated cells of that system. At its rostral pole it extends just above the anterior commissure and is a bilateral structure in the form of a band on each side of the midline, laterally bounded by the nucleus parataenialis and ventrally by the descending columns of the fornix and, more caudally, by the nucleus filiformis anterior. In the region of the commissural nuclei these occupy the position of its ventral portion, and the dorsal portion only is present, bounded by the floor of the ventricle medially, by the stria medullaris dorsally, the nucleus parataenialis laterally, and the commissural group ventrally (figs. 1 to 4). Behind the commissural nuclei it becomes a midline structure, consisting of several vertically running bands of cells which fuse with each other at places (fig. 5). Dorsally, it extends for a short distance under the floor of the ventricle and ventrally fuses with the dorsal surface of the nucleus centralis medialis. The nucleus paraventricularis anterior is separated here from the nuclei mediales dorsales of the two sides by fibers of the periventricular system. Caudally, the cells are smaller and the nucleus as a whole less differentiated, until at the level of the anterior pole of the habenular complex it can no longer be distinguished as a structure separate from the periventricular system of fibers (fig. 6). Throughout its extent the dorsal portion, which forms a Y under the floor of the ventricle, is the best-differentiated part. It is separated from the ependyma of the ventricle by a thin fiber layer and is bounded dorsally and dorsolaterally by the nucleus parataenialis and the nucleus medialis dorsalis, one behind the other.

The arrangement of the cells throughout is vertical, among the fibers of the periventricular system. The cells are small, fusiform, with a small amount of granular, moderately deeply stained cytoplasm and one or two long cytoplasmic processes. The nuclei are very large in relation to the size of the cells; they are round or oval, pale, with a rather coarse chromatin network and a single, large, deeply stained nucleolus. The nucleus, from its position, cellular arrangement, and form, is apparently a differentiated part of the periventricular system.

Nucleus paraventricularis posterior. This nucleus extends as a ribbon of cells along the wall of the ventricle from the caudal end of the anterior third of the habenula to the rostral end of the habenular commissure (figs. 7 to 9). It is separated from the ependyma of the ventricle medially and from the nucleus tractus habenulo-peduncularis medialis and the nucleus parafascicularis laterally by fibers of the periventricular system, which also bound it dorsally and ventrally. It extends from a short distance below the habenula almost to the level of the internal medullary lamina. It attains its greatest dimensions at the level of the nucleus parafascicularis, and is finally replaced by the periventricular system caudally at the level of the rostral part of the habenular commissure. The cellular arrangement and form are similar to those of the nucleus paraventricularis anterior, although the cells on the whole are somewhat smaller.

Nucleus reuniens. The nucleus reuniens is the most ventral of the nuclei of the midline in the rostral portion of the thalamus. It lies in the ventromedial corner of the dorsal thalamus, just dorsolateral to the roof of the infundibular portion of the ventricle, from which it is separated by the periventricular system. Its rostral pole lies at the anterior end of the thalamus, being rostrally bounded by the descending columns of the fornix. In this region the nucleus is large and oval in cross-section, consisting of a dorsolateral large-celled portion and a ventromedial small-celled portion (fig. 1). Here it extends dorsally between the nucleus anteromedialis and the midline, and there is no sharp line of demarcation between it and the anterior poles of the nucleus submedius and the nucleus ventralis medialis, the cells of all three being lined up between the fibers of the inferior thalamic peduncle (figs. 1 and 2). A few sections farther caudalward, however, the nucleus reuniens is bounded dorsally by the nucleus centralis medialis and the nucleus submedius and laterally by the nucleus ventralis pars medialis (fig. 3). For the most part it is separated from the midline by fibers of the periventricular system, although in places it appears to be definitely commissural (fig. 5). The ventral boundary, throughout its extent, is formed by the external medullary lamina. In passing caudalward, the nucleus reuniens becomes considerably smaller and triangular in shape. The dorsolateral, large-celled portion rapidly diminishes in size and disappears just caudal to the anterior pole of the nucleus submedius. A little farther caudalward, the nucleus ventralis medialis extends between the nucleus reuniens and the nucleus submedius and bounds the former dorsally and medially (fig. 6). The two are separated by a thin fiber layer. At its caudal pole the nucleus reuniens becomes very small and poorly differentiated, and finally fuses with the nucleus commissuralis interventralis, which lies just caudal to it (fig. 7).

In the cat the nucleus reuniens is a much larger structure, being one of the prominent nuclei in the rostral part of the thalamus. It has a definite, large commissural portion, with large, well-demarcated lateral projections, similar to the structure described in rodents.

In the rostral portion of the nucleus reuniens of the dog the cells are lined up between the fibers of the inferior thalamic peduncle, but in the caudal portions they are irregularly arranged. The cells of the dorsolateral portion are medium in size, triangular to fusiform in shape, with diffusely granular, rather pale cytoplasm and several, moderately long, cytoplasmic processes. The nuclei are moderately large, oval, and pale, with a faint diffuse chromatin network and a single, small nucleolus. The cells of the ventromedial, or main, portion of the nucleus are small and quite similar to the cells of the commissural nuclei, though not so densely grouped. They are somewhat larger and stain more deeply than the cells in the periventricular system of fibers and may be regarded as occupying a position between these and the cells of the commissural group.

Periventricular system. The periventricular system is a system of fibers with very small, poorly differentiated cells intercalated between them, running vertically along the midline, connecting the ventral with the dorsal thalamus. It is only in part interrupted by the commissures of the dorsal thalamus and their bed nuclei, and as a whole it forms the medial boundary of the thalamus.

It is evident from the literature that the commissural group of nuclei is much more highly developed in lower than in higher mammals. The great majority of authors merely mention the 'commissura media' or the 'central gray.' The only detailed analyses of this group have been carried out on rodents, Ramón y Cajal ('11), Nissl ('13), d'Hollander ('13), and, most completely, Gurdjian ('27). The nucleus reuniens, as described in rodents, consists of a commissural and lateral parts. It is possible that the ventral portion of the nucleus centralis medialis, in dog, is homologous with the commissural portion of the rodent nucleus reuniens.

In carnivores Winkler and Potter ('14, cat) showed a commissura media, which is equivalent to the bed nuclei of the commissures associated with the anterior and medial nuclear groups; a nucleus reuniens, equivalent to the nucleus rhomboidalis of the present account; a nucleus centralis (a), homologous with the nucleus centralis medialis. In figures XI and XI A, they showed an unlabeled group of cells comparable in position to the nucleus reuniens of the above account. It is possible that the group labeled *M a,* in their figure X A, is also nucleus reuniens. Papez ('29) did not mention the commissural group otherwise than as the massa intermedia (p. 301, fig. 169, *mi*). In this same figure the cell mass labeled nucleus reuniens (*reu*), is nucleus centralis lateralis. His nomenclature follows that of Malone ('10).

In primates the work of Vogt ('09), Friedemann ('12), and Pines ('27) indicates that the midline group is very greatly reduced. In recent description of human material the presence of any commissural fibers in this region has been questioned.

Lateral group of nuclei

The lateral nucleus, together with the closely associated pulvinar and posterior nucleus, forms the dorsolateral mass of the thalamus throughout almost its whole extent (figs. 4 to 12, 16 to 18). In the dog the following parts may be differentiated: lateral nucleus, pars anterior, pars intermedia, pars posterior; nucleus suprageniculatus; nucleus limitans; pulvinar; area pretectalis; nucleus posterior; nucleus reticularis. These divisions are based on differences in the types and arrangements of the cells, but it is practically impossible to draw any sharp boundary lines, especially in the posterior regions.

Nucleus lateralis, pars anterior. The nucleus lateralis, pars anterior, is a mass of cells in the lateral anterior region of the thalamus, forming roughly a triangular pyramid, the apex of which extends into the tuberculum anterius at the level of the middle of the optic chiasm (figs. 4 to 6). The base faces caudad, is concave in shape, and forms the rostral boundary of the pars intermedia of the lateral nucleus, at the level of the rostral border of the infundibulum (fig. 18). The boundaries of this portion are well marked on all sides. Dorsally, it is separated from the ependyma of the third ventricle by a thin layer of fibers, the stratum zonale. Medially, in its rostral three-fourths, it is separated from the nucleus anterodorsalis and nucleus anteroventralis by the internal medullary lamina, and in its caudal quarter from the nucleus centralis lateralis by a fiber layer containing intercalated cells. The ventral boundary, in its extreme rostral portion, is formed by a fiber layer between it and the nucleus ventralis, pars anterior (fig. 18). Caudoventrally and caudally, the boundary is formed by the pars intermedia of the lateral nucleus (fig. 5). The parts are continuous, but are demarcated by the difference in character of the cells, and there is very little intermingling of the cells along the line of juncture. Laterally, the nucleus forms the lateral margin of the thalamus, with the external medullary lamina lying between it and the nucleus reticularis. In general, the cells of the pars anterior of the lateral nucleus lie moderately far apart and their arrangement is irregular, although they tend to line up with the fibers passing through, which are more or less parallel to the surfaces of the nucleus in its various regions. This arrangement is most marked in the dorsomedial portion. Bundles of fibers of the thalamic radiations passing through the nucleus in places appear to further subdivide it. However, no intrinsic differences between these portions can be made out.

The cells (fig. 22, A) do not vary greatly in size. In sagittal sections those of the posterior half of the nucleus appear larger and more clearly stained than those of the anterior half. The cells are slightly smaller than those of the nucleus anterodorsalis and stain less deeply. They are polygonal and triangular in shape and have very long cytoplasmic processes. The cytoplasm contains blotchy granulations. The nuclei resemble the nuclei of the cells of the nucleus anterodorsalis, but stain more deeply. There is a definite chromatin network and a single, deeply stained nucleolus.

Nucleus lateralis, pars intermedia. This is a mass of cells in the form of a thick, convex lens, lying caudal to the pars anterior (fig. 18). Its limits are best made out in the sagittal sections, where it is macroscopically visible, due to its greater apparent density. The vertical axis is tilted slightly, so that the ventral pole lies rostrally at the level of the nucleus centralis lateralis (fig. 5), while the dorsal pole extends caudally through the first quarter of the habenular complex (fig. 7). The rostral boundary is formed in the dorsal region by the pars anterior of the nucleus lateralis, in the medioventral region by the nucleus centralis lateralis, and in the ventrolateral region by the nucleus ventralis, pars anterior. The pars intermedia is separated from the nucleus centralis lateralis by a fiber band containing numerous, small, intercalated cells, apparently continuous with the cells of the pars intermedia. In the lateral part of the ventral-rostral border there is a narrow sheath of fibers which extends, like a knife, into the substance of the ventral nucleus (figs. 5 and 18). Among the fibers are numerous, elongated, rather pale, intercalated cells which seem to be continuous with the cells of the pars intermedia. (It is around this sheath of fibers that the large cells of the ventral nucleus, with their small, deeply stained nuclei, first appear.) Dorsally, the pars intermedia extends to the surface of the thalamus, reaching the stria medullaris medially, and being covered dorsally by the very thin stratum zonale. The medial boundary is formed by the nucleus centralis lateralis, except along the caudomedial margin, where the pars posterior of the lateral nucleus extends between the two (figs. 6 and 7). The ventral boundary is formed by the ventral nucleus, pars externa and pars arcuata. Laterally, the pars intermedia extends to the external medullary lamina which separates it from the nucleus reticularis. Caudally and caudolaterally, the pars intermedia is bounded by the pulvinar; caudomedially, by the pars posterior, and caudodorsally is continuous, in its dorsal portion, with the pretectal area (fig. 8).

The boundaries between the pars intermedia and the following groups, namely, the nucleus ventralis, the pulvinar, and the pars posterior of the lateral nucleus, are by no means sharp. They consist of areas of fibers, with more or less numerous intercalated cells, and there is considerable intermingling of the cells, especially with the pretectal area and the pulvinar.

The nucleus lateralis, pars intermedia, can be subdivided into three parts on the basis of cell form and arrangement, namely, a dorsal portion, which runs into the pretectal area caudally; a lateral portion, which is continuous with the lateral portion of the pulvinar, but which is differentiated from the latter by the greater density of cellular arrangement; and a medial portion, which adjoins the pars posterior and is only separated from it by a thin fiber layer. There are no sharp boundaries between these three parts, one going over into the other by gradual degrees.

The cells of the medial portion of the pars intermedia are irregularly arranged in groups and whorls, depending on the course of the fibers of passage. In general, the direction is oblique. The cells (fig. 22, B) are small, elongated triangular or polygonal, with moderately well-stained, slightly granular cytoplasm containing a relatively large amount of pigment. The nuclei are small, oval, and do not stand out distinctly, with single, deeply staining nucleoli, but no definite chromatin network.

The group of cells extending down between the fibers which run into the nucleus ventralis from the rostral pole of the pars intermedia differ in that they are much more elongated, the cytoplasm being paler and more homogeneous. In the lateral portion of the pars intermedia the cells are similar in form and structure to the cells of the medial portion. They are lined up, however, in layers between fibers running horizontally from the outside in and from in front backward. Through this region there are also rather numerous scattered cells which are larger and which resemble the cells of the pulvinar (see below).

The boundary between the lateral and medial portions of the pars intermedia is formed by a band of fibers and cells running downward from the dorsolateral corner of the nucleus. These cells, and also the cells in the dorsolateral corner with which they are continuous, are arranged vertically and are somewhat larger and paler. The nuclei and cytoplasmic structure is otherwise similar to the rest of the cells of the region. The last-mentioned area becomes continuous with the dorsal portion of the pars lateralis of the pulvinar.

The dorsal portion of the pars intermedia lies dorsal and dorsomedial to the medial portion. The cells are slightly larger and paler and are less densely arranged. They lie more or less lined up along fibers running parallel to the floor of the ventricle. This region becomes continuous with the pretectal area caudally.

Nucleus lateralis, pars posterior. In the posterior regions of the thalamus not only do the nuclei become less definitely demarcated structures, but also the cells are less differentiated and in position and arrangement are more dependent on the presence and direction of fiber bundles. The pars posterior of the lateral nucleus is a region rather than a single part of the nucleus. It is demarcated by fiber layers running between it and the surrounding structures, which for the most part are fairly distinct, though at places they contain numerous intercalated cells and are not very clear. The pars posterior extends as a layer of varying thickness, appearing in cross-section as an obtuse triangle, from about the level of the rostral pole of the habenular complex rostrally to the level of the caudal planes of the habenular commissure caudally (figs. 6 to 10). The rostral pole extends ventral to the pars intermedia of the lateral nucleus, from which it is indefinitely separated by a thin layer of fibers, containing intercalated cells. Medially, it is bounded in its rostral half by the nucleus medialis dorsalis above and the nucleus centralis lateralis below, in its caudal half at first by the nucleus parafascicularis, and finally by the nuclei of the commissura posterior. In its medial third the dorsal portion of the pars posterior extends medially to the ventrolateral border of the habenular complex. Ventrally, it is bounded by the nucleus ventralis. Laterally, the dorsal portion is bounded in part by the pretectal area (fig. 9), the ventral portion is bounded at first by the pulvinar and more caudally by the posterior nucleus. The dorsal boundary is formed by the stratum zonale. Caudally, the pars posterior of the lateral nucleus becomes continuous with the dorsal portion of the nucleus geniculatus medialis. The pars posterior of the nucleus lateralis may be divided into three parts: a ventral portion, a middle portion, and a dorsal portion. This differentiation is based mainly on the arrangement of the fibers of passage and on the arrangement of the cells, rather than on their structure.

The ventral portion (fig. 8) lies between the pulvinar and the posterior nucleus above and the nucleus ventralis below. It consists of small cells, elongated triangular or fusiform, with slightly granular, rather pale cytoplasm and long processes. The nuclei are large, oval, pale, with a single nucleolus and no definite chromatin network. The cells lie for the most part horizontally, intercalated between the fibers that swing in from the internal capsule in this region. Some of these fibers turn up to the lateral nucleus and pulvinar, some pass to the medial regions of the thalamus, and some go to form the capsular system of the nucleus ventralis. Thus, the ventral portion of the pars posterior comes to be closely associated with all its surrounding structures, forming part of the reticular system of intercalated cells among the incoming and outgoing fiber systems. In its rostral portions it is continuous with similar cells along fibers which run medially between the central and the ventral nuclei. This is part of the capsular system of the ventral nucleus, and the cells fuse medially with the small cells of the medial portion of the nucleus ventralis. This medial extension continues to the caudal portions of the nucleus centralis medialis. More caudally, the ventral portion of the pars posterior of the lateral nucleus becomes sharply demarcated medially by the internal medullary lamina as it forms a capsule around the nucleus parafascicularis. Ventrally, it is demarcated by the layer of large cells of the nucleus ventralis, pars arcuata. Just rostral to the anterior pole of the nucleus posterior, the extreme lateral cells of the ventral portion of the pars posterior of the lateral nucleus appear larger, less undifferentiated, and more or less separated from the medial portion by obliquely running fibers. With the development of the posterior nucleus this group is pressed ventrally, as it were, to form a cap over the anterior pole of the nucleus geniculatus medialis. From here caudally the ventral portion of the pars posterior of the lateral nucleus becomes more and more intimately associated with the dorsal portion of the nucleus geniculatus medialis, until it is impossible to draw any line between them. At places there is fusion with the ventrolateral portion of the posterior nucleus also. The cells lie closer together than in the rostral portions, stain slightly more deeply, but maintain their original structure and are elongated, drawn out between fibers running obliquely inward and upward from the capsule of the nucleus geniculatus medialis.

The medial portion (fig. 8) of the pars posterior of the lateral nucleus is more or less separated from the ventral portion by a cell-poor zone of fibers running horizontally into and out of the ventral and medial regions of the medial group of nuclei. It is separated from the dorsal portion by similar fibers between the medial group of nuclei and the lateral nucleus and pretectal area. The cells of this portion resemble those of the ventral portion, except that they are slightly larger, less elongated, and tend to line up with fiber bundles in the region less than do the cells of the ventral portion. They are closely associated with the cells of the pulvinar and also of the nucleus medialis dorsalis, the boundaries being almost obliterated at places. The medial and lateral boundaries are formed by thin bands of obliquely running fibers, containing small, intercalated cells parallel with the fibers. The medial portion attains its largest dimensions in its middle third. Caudally, it fuses with the ventral portion to form the nucleus suprageniculatus (p. 45). The most striking feature in this region is the presence of several nests of cells, mostly in the medial portion of the pars posterior of the lateral nucleus, but also a few in the lateral margin of the parafascicular nucleus, in the caudal part of nucleus centralis lateralis, and in the medial margins of the pulvinar and pretectal area. These nests appear at the level through the medial portions of the parafascicular nucleus and disappear at the level of the posterior part of the same. The cells forming the nests are apparently arranged along fibers, but, being cut at different angles, some of them appear round, others elongated. Their cytoplasm is somewhat granular, stains moderately deeply, and they have fewer and shorter processes than the other cells of the region. The nests are from five to eight cells in diameter.

The dorsal portion of the pars posterior of the lateral nucleus (figs. 8 and 9) is closely associated with the pretectal area on the one hand and with the dorsal portions of the nucleus medialis dorsalis on the other. The ventral boundary of this whole dorsal group is formed by an indistinct fiber zone, in which the cells are lined up parallel with the fibers, running horizontally out from the level of the ventral margin of the habenular complex, the fibers apparently connecting these three zones with each other. The cells of the dorsal portion of the pars posterior of the lateral nucleus are slightly larger than the cells of the medial and ventral parts. They are scattered quite far apart and have a slightly granular, moderately well-stained cytoplasm and long processes. The nuclei are large and pale, with a single nucleolus and no definite chromatin network. The most dorsal of the cells are lined up between fiber bundles running parallel with the floor of the ventricle. Below these the cells seem to radiate downward. In the caudal third of the pars posterior its dorsal portion increases in size so that it extends medially to the ventrolateral margin of the habenular complex. Caudal to this the dorsal portion rapidly decreases in size and is finally bounded by the brachium of the superior colliculus.

Nucleus suprageniculatus. At the posterior levels of the nucleus parafascicularis, apparently due to the size of the nucleus geniculatus medialis, the ventral and medial portions of the pars posterior of the lateral nucleus become pressed together and united. In this region there are two groups of cells which are sufficiently distinct in the sections to be considered as entities. The more ventral of these two, the nucleus suprageniculatus, consists of two or three groups of elongated cells (fig. 10), apparently condensations of cells of the ventral portion, extending dorsomedially from the anterior pole of the nucleus geniculatus medialis, through the ventral portion into the medial portion of the pars posterior of the lateral nucleus. These correspond to a group described in the monkey as the area suprageniculata by Friedemann ('12). It is not possible to determine from their structure whether they are to be considered as part of the internal geniculate or of the lateral nucleus. Their cells lie closer together and are somewhat more deeply stained than are the cells of the pars posterior, but otherwise resemble them. They are somewhat more elongated than the cells of the medial geniculate.

Nucleus limitans. The more dorsal of the two groups mentioned, nucleus limitans (figs. 9 and 10), lies in the internal medullary lamina, being a condensation of the cells in that region, occupying a position which, in the rostral planes, is occupied by the nucleus centralis lateralis. These cells are small, elongated, lying closely together, arranged along the obliquely running fibers of the internal medullary lamina. Thus they lie between the pars posterior laterally, the commissural gray medially, and the nucleus geniculatus internus ventrolaterally. Broken groups of cells intercalated between the fibers of the internal medullary lamina connect them rostrally with the central nuclear complex, but as they are poorly differentiated cells, it is not possible to tell from their structure with which of the groups or complexes they should be classed. They correspond to the nucleus limitans described in the monkey by Friedemann ('12).

Pulvinar. In the dog the pulvinar forms a rather poorly demarcated portion of the lateral group of nuclei. Its rostral pole (fig. 7) extends a few sections rostral to the nucleus geniculatus lateralis dorsalis and its caudal pole lies at about the level of the beginning of the caudal quarter of the latter (fig. 10). From the lateral border of the thalamus it extends medially, like a thick wedge, its inferior surface sloping mediodorsocaudally. The rostral boundary (fig. 18) is formed by the pars intermedia of the lateral nucleus, the boundary being very indistinct in the lateral portions. The dorsal boundary is formed by the area pretectalis (fig. 8). The pars posterior of the lateral nucleus forms the medial boundary (fig. 8). The ventral boundary is formed at first by the nucleus lateralis, pars posterior. More caudally, the caudoventral and finally the caudal boundaries are formed by the nucleus posterior. Laterally, the pulvinar is separated from the nucleus geniculatus lateralis by capsular fibers of the latter. The pulvinar may be divided into three parts (fig. 8), mainly on the basis of cellular arrangement: a lateral superior portion, a lateral inferior portion, and a medial portion.

The cells of the lateral superior portion are lined up along fibers which swing in around the medial margin of the dorsal horn of the nucleus geniculatus lateralis dorsalis. These fibers run medially and then ventrally, extending downward through the pulvinar separating the medial from the lateral portions. The lateral superior portion of the pulvinar is small, comprising only that area just medial to the dorsal horn of the lateral geniculate. Rostrally, it is continuous with the dorsolateral corner of the pars intermedia of the lateral nucleus, in which the cells are similarly arranged. It contains two types of cells, small cells, similar to those of the pars intermedius of the lateral nucleus, and large cells, similar to the largest neurones of the lateral portion of the pulvinar.

Groups of these large cells accompany the ventrally running fibers, scattered along their course, between the lateral and medial portions of the pulvinar. At about the beginning of the caudal half of the pulvinar the lateral superior portion becomes continuous with the laminae parvocellularis and tinguishing feature. Caudal to the lateral inferior portion of the pulvinar the medial portion is still present, dorsally continuous with the pretectal area, laterally bounded by the small-celled layer of the lateral geniculate, ventrally and caudally bounded by the posterior nucleus.

Area pretectalis. The pretectal area (figs. 8 to 11) is an irregularly oblong group of cells lying under the floor of the third ventricle, rostrally continuous with the dorsal portion of the pars intermedius of the lateral nucleus. Medially, it is bounded by the dorsal portion of the pars posterior of the lateral nucleus, the line of demarcation at places being very indistinct. Ventrally, it is more or less continuous with the medial portion of the pulvinar, except in its caudal quarter, where the posterior nucleus replaces the latter. The boundary between the pretectal area and the posterior nucleus is also a matter of conjecture. Laterally, it is bounded at first by the superior lateral portion of the pulvinar and, more caudally, by the lamina parvocellularis of the lateral geniculate. Caudally, it is separated from the tectal gray by a fiber layer, the brachium of the superior colliculus, which contains a few, moderately large, irregularly arranged, intercalated cells. The more dorsal of the cells of the pretectal area are arranged horizontally, in line with fibers running parallel to the floor of the third ventricle. Below this the cells are more irregularly arranged, as though radiating down from the dorsal layer, in line with fibers running longitudinally. The cells (fig. 22, C) are individually very similar to those of the pars anterior of the lateral nucleus. However, they lie closer together, tend to line up with fibers passing through, and have a somewhat more deeply stained cytoplasm.

Posterior nucleus. The posterior nucleus is a wedge-shaped mass of cells in the caudolateral region of the thalamus, lying between the nucleus geniculatus lateralis and the nucleus geniculatus medialis. The rostral pole becomes differentiated from the cells of the ventrolateral corner of the pulvinar, with no definite line of demarcation, just caudal to the anterior pole of the nucleus geniculatus lateralis dorsalis (fig. 9). The caudal pole lies at the level of the caudal extreme of the lateral geniculate (fig. 12). In the rostral third the dorsolateral boundary is formed by the lateral portion of the pulvinar. In the middle and caudal thirds the lateral boundary is formed by the medial extension of the lamina parvocellularis of the lateral geniculate, with considerable intermingling of the cells, especially in the caudal planes (figs. 10 to 12). The dorsal boundary, in the rostral third, is formed by the medial portion of the pulvinar; in the caudal two-thirds it is formed by the pretectal area (figs. 10 to 12). The line of demarcation between the pulvinar and the area pretectalis and the posterior nucleus is nowhere clear-cut, especially in the caudal portions where it is not possible to tell cytoarchitectonically where one begins and the other ends. The ventromedial boundary is formed rostrally by the pars posterior of the lateral nucleus and caudally by the medial geniculate. In the caudal third there is a fusion of the posterior nucleus with the medial geniculate complex ventrally. Caudally, the posterior nucleus is bounded by the brachium of the superior colliculus. The cells are arranged along diagonally running fiber bundles. In cross-sections the cells look elongated (fig. 22, D), in sagittal sections they are polygonal, about the size of the larger cells of the lateral nucleus, and closely resemble these in structure, both as to cytoplasm and nuclei.

Nucleus reticularis. The nucleus reticularis forms a layer of cells around the lateral and rostrolateral surfaces of the thalamus in relationship with the fibers of the thalamic radiations. Its medial aspect is bounded by the external medullary lamina which separates it from the lateral and ventral thalamic nuclear groups. The lateral aspect is in relation with the internal capsule. At its anterior pole, which lies just caudal to the commissura anterior, it consists of two layers of cells, an outer and an inner. The outer layer is continuous rostrally with the cells of the nucleus lateralis striae terminalis. The inner layer is continuous rostrally with the nucleus medialis striae terminalis. Passing caudally, the two layers more or less fuse, the outer layer becoming smaller, the inner layer larger (fig. 1), until about the level of the middle of the inferior thalamic peduncle the outer layer can no longer be seen. Through the remainder of its extent the nucleus reticularis may be divided into a dorsal and a ventral portion, the dorsal portion being in relation with the superior thalamic radiations, the ventral in relation with the lateral thalamic radiations. However, as there is no evidence that there is any intrinsic difference between these two portions in function and as the difference in the size of the cells at different levels is more probably due to the angle at which they are cut by the sections than to actual differences in measurements, it is probably better to consider the nucleus as a whole rather than to subdivide it. At its ventral extremity it fuses with the zona incerta and there is a rather striking resemblance between the cells of these two regions (figs. 5 to 8). At the level of the middle third of the nucleus geniculatus lateralis the nucleus reticularis is divided into two separate parts (figs. 9 and 10), the dorsal consisting of scattered cells among the fibers of the optic radiations as they sweep through the hilus of the geniculate, the ventral lying in the angle between the optic tract and the lateral border of the peduncle and extending in a dorsolateral direction to mix with the cells of the nucleus geniculatus lateralis ventralis. The dorsal part ends at the posterior limits of the optic radiations and the ventral part at the posterior limits of the auditory radiations. The cells lie in groups between the fibers, forming a coarse reticulum, with many cells scattered out into the internal capsule and occasionally medially into the external medullary lamina where they intermingle with the cells of the nucleus ventralis externus. For the most part, however, the layer is quite distinct and shows a moderately well-stained groundsubstance.

The neurones (fig. 22, E) vary in size from moderately large cells to those almost as large as the large cells of the ventral nucleus. They tend to be smaller in the region adjoining the zona incerta. They vary in shape from rounded polygonal to fusiform, apparently depending on the direction of section. They have numerous, long, branching cytoplasmic processes. The cytoplasm contains coarse, blotchy granulations diffusely scattered. The nuclei are large, occupying about half of the area of the cell, with a faint, rather diffuse, chromatin network and single, deeply stained nucleoli.

The increase in size of the higher mammalian thalamus is due to a great extent to the development of this lateral group of nuclei. Observers studying the marsupial (Tsai, '25), insectivore (Le Gros Clark, '29), and rodent (Nissl, '13; d'Hollander, '13; Gurdjian, '27) brains have described a differentiation of the lateral group corresponding to four functional areas. These may be classed as 1) a relatively small lateral nucleus, 2) a posterior part of this, which they suggest may be a rudimentary pulvinar, 3) a large pretectal area (nucleus praebigeminus of Nissl, '13, and Tsai, '25), and, 4) a nucleus posterior. The basis for this division lies in the fiber connections to specific areas. The lateral nucleus is associated with the cortex, its posterior part, or rudimentary pulvinar, also receiving optic fibers. The pretectal area is characterized by its connections with the optic tectum and the nucleus posterior by its fiber relations to the lemniscal system. At the other end of the mammalian scale it is evident from the reports of Vogt ('09), Friedemann ('12), and Pines ('27) that the development has occurred particularly in the lateral nucleus and the pulvinar, that the pretectal area has greatly decreased in importance, and that the posterior nucleus has remained relatively the same. This is to be expected from the increased development of the cortex and particularly of its visual area, and the decrease in dominance of the optic tectum. The stability of the posterior nucleus probably is dependent on its relations with the lemniscal system. The development within the lateral nucleus itself is indicated not only by its increased size, but also by its differentiation into secondary groups. These groups are more numerous in primates than in dog. With our present lack of knowledge of the incoming and outgoing fiber systems of such secondary groups in both primates and carnivores, it is impossible to draw exact homologies between specific portions of the lateral nucleus in the two types. A comparison of the lateral nucleus of rodents, carnivores, and primates indicates that this nucleus develops from a single cell mass into an increasingly complex series of interrelated nuclear groups, indicated by differences in cytoarchitectonic structure and fiber connections. Such an interpretation of necessity implies that the underlying causes of this differentiation are to be sought in an increase in functional specialization.

The accounts dealing with carnivores directly are to be found in the papers of von Monakow ('95), Winkler and Potter ('14), Papez ('29), and others. von Monakow and Papez described an anterior dorsal part of the lateral nucleus, comparable with the nucleus lateralis, pars anterior, of the above description, and a nucleus lateralis, which they did not divide further, but into the posterior part of which they carried optic fibers. von Monakow also described a posterior nucleus. Winkler and Potter showed a nucleus lateralis (a), equivalent to the pars anterior, a nucleus lateralis (b), equivalent to the pars intermedia and pars posterior, a pulvinar, situated dorsally and caudally, and a nucleus posterior.

Ventral group of nuclei

The ventral nuclear group, as a whole (figs. 1 to 10, 15 to 18), forms the ventrolateral mass of the thalamus proper. In general appearance it gives the impression of a partially inflated toy balloon which is being compressed dorsomedially by the medial group of nuclei, ventrally by the hypothalamus, and caudolaterally by the geniculate bodies, so that it is bulging out in an anterodorsolateral direction. The boundaries, in general, are as follows: rostrally, at the level of the anterior margin of the optic chiasm, it is separated from the rostral portion of the nucleus reticularis by the external medullary lamina, forming the most anterior portion of the lateral thalamic region (fig. 18). Dorsomedially, the anterior pole is bounded by the nucleus anteromedialis (figs. 1 to 3). More caudally, it fuses with the anterior pole of the nucleus centralis lateralis (fig. 4) and then is separated from the latter by the fibers of the internal medullary lamina. With the development of the nucleus lateralis pars intermedius, a medial prolongation of the latter extends between the nucleus ventralis and the nucleus centralis lateralis (fig. 5). More medially still, the nucleus ventralis is separated by fibers of the internal medullary lamina from the nucleus paracentralis and by a narrow band of fibers from the nucleus submedius. Caudal to this the fibers of the internal medullary lamina again form the dorsomedial boundary, separating the nucleus ventralis from the nucleus parafascicularis and from the interstitial nucleus of the commissura posterior to the point where the most caudal cells of the nucleus ventralis fuse along dorsomedially running fibers with the caudal pole of the nucleus limitans (figs. 9 and 10). The dorsal boundary is formed by the nucleus lateralis, at first by the pars anterior, then by the pars intermedius, with its medial projection, and behind it by the ventral portion of the pars posterior, which similarly projects in a thin band medially, between the nucleus ventralis and the caudal pole of the nucleus centralis lateralis (figs. 6 to 8). At the caudal pole of the nucleus ventralis the dorsal boundary is formed by the nucleus suprageniculatus, which is continuous with the dorsomedial portion of the medial geniculate body (figs. 9 and 10). The medial boundary is formed by the nucleus reuniens at the anterior pole. Caudal to this it is formed by the periventricular system of fibers, with the nucleus submedius dorsomedially and the nucleus reuniens ventromedially (figs. 3 to 6). There is no sharp line of demarcation between the nucleus ventralis and the periventricular system of fibers, the two apparently fusing, but the nucleus ventralis is separated from the other two nuclei by a thin band of fibers, though at places these also seem to fuse with it. Caudal to the nucleus reuniens lies the commissural portion of the nucleus ventralis (fig. 8), connecting with the nucleus of the opposite side. Behind this, again, the caudal pole of the nucleus ventralis becomes separated from the midline by the periventricular system of fibers and then is bounded medially by the nucleus subparafascicularis (fig. 9). The ventral boundary is formed throughout by the external medullary lamina, which separates it from the hypothalamus to the point where the nucleus subparafascicularis finally forms the medial portion of the caudal boundary (fig. 9). The lateral boundary is also formed by the external medullary lamina to the level of the anterior pole of the medial geniculate. Behind this the lateral and caudal boundaries are formed by the medial geniculate. The ventral nucleus can be divided into five divisions, differentiated on the basis of cellular structure and arrangement, namely: anterior, arcuate, external, medial, and commissural.

Nucleus ventralis, pars anterior. This group forms the anterior pole of the ventral nucleus, extending caudally to the sheath of fibers connected with the pars intermedius of the lateral nucleus (fig. 5). Rostrally, it is bounded by the external medullary lamina. Mediodorsally, it joins the ventrolateral margin of the nucleus anteromedialis (figs. 1 to 3); more caudally, it is bounded here by the nucleus centralis lateralis, with which it seems to fuse, due to the lining up of the cells of each in horizontally running fibers of the lateral thalamic radiations (fig. 4). The caudal pole is separated from the nucleus centralis lateralis by the pars intermedia of the lateral nucleus, which extends between them (fig. 5). At the anterior pole it is bounded ventrally by the external medullary lamina, but a few sections more caudally the ventromedial portion becomes continuous with the pars medialis and the ventrolateral portion continuous with the pars externa of the ventral nucleus (fig. 2). These two parts then bound the pars anterior ventrally. More caudally, the pars arcuata of the ventral nucleus displaces the pars medialis and forms the ventromedial boundary (fig. 3). With the development of the fiber layer, or sheath of fibers, connected with the pars intermedia of the lateral nucleus, which extends ventrally into the substance of the ventral nucleus, the caudal pole of the pars anterior is separated from the other parts by these fibers ventrally and finally terminates as a small group of typical cells among them (fig. 5). The lateral boundary throughout is formed by the external medullary lamina. The dorsal boundary is formed at first by the nucleus anteroventralis and the external medullary lamina. More caudally, the pars anterior of the ventral nucleus comes into close relationship with the pars anterior of the lateral nucleus (fig. 17).

In the anterior portion the cellular arrangement is irregular, the cells lying moderately far apart, without particular reference to the fibers. More caudally, especially at the level of the anterior pole of the nucleus centralis lateralis, the cells are arranged between horizontally running fibers. At no place, however, are they distributed in a reticular fashion, as are the cells of the other portions of the ventral nucleus. The cells (fig. 23, A) are large, polygonal, with several moderately long cytoplasmic processes. The cytoplasm is diffusely granular and stains about as deeply as that in the nucleus anteroventralis. The nuclei are large and pale, showing a very faint chromatin network and single, deeply stained nucleoli.

Nucleus ventralis, pars medialis. The nucleus ventralis, pars medialis, forms the medial portion of the ventral nucleus. Its rostral pole is continuous with the ventromedial portion of the pars anterior and extends dorsolaterally, forming a cap over the medial portion of the pars arcuata (figs. 3 and 4). More caudally, where the pars arcuatus is considerably larger, the pars medialis lies entirely medial to it. The dorsal boundary is quite distinct, being formed by the nucleus submedius and by the internal medullary lamina. The medial boundary at the rostral pole is formed by the inferior thalamic peduncle with its intercalated cells (fig. 2). Caudal to that it is formed by the nucleus reuniens and the periventricular system of fibers and intercalated cells. There is no sharp line of demarcation between the pars medialis and the periventricular system, the transition from one into the other being quite gradual. It also fuses with the caudal pole of the nucleus reuniens (figs. 6 and 7), and, at about the same level, replaces the nucleus submedius in the angle between the midline and the internal medullary lamina. The ventral boundary is formed by the external medullary lamina throughout, separating it from the hypothalamus. The lateral boundary is the pars arcuata and the pars externa of the ventral nucleus, with both of which parts there is more or less fusion. Caudally, the pars medialis goes over into the pars commissuralis interventralis, the distinction between the two being possible only in the sagittal sections where the cells of the pars commissuralis appear concentrically arranged (figs. 15 and 16). It is to be noted that the mammillo-thalamic tract runs through the pars medialis in a compact bundle until it reaches the boundary of the nucleus submedius, where it begins to spread out.

In the rostral portion the cells (fig. 23, B) are arranged in a regular, coarse network, by diagonally running fibers. They are of medium size, polygonal, with several moderately long cytoplasmic processes. There are no large cells. The cytoplasm is diffusely granular, stains somewhat more deeply than does that of the cells of the nucleus submedius, but not as deeply as that of the cells of the pars arcuata of the ventral nucleus. The nuclei are relatively large, oval, pale, with faint chromatin network and single deeply stained nucleoli. More caudally, the cells become smaller and tend to be arranged along medially running fibers and along fibers to and from the periventricular system. The cells along the border of the nucleus reuniens are grouped more closely, are smaller, rounded in shape, with two to four short cytoplasmic processes and a small amount of quite deeply stained, diffusely granular cytoplasm. The nuclei resemble those of the other cells of the pars medialis. At the caudal pole, where the pars ventralis fuses with the pars commissuralis, the cells all become smaller, paler, and lined up in horizontally running fibers.

Nucleus ventralis, pars externa. The pars externa, together with the pars arcuatus, forms the principal portion of the nucleus ventralis. It lies as a highly differentiated capsule around the pars arcuata, rostrally, laterally, and ventrally. It attains its greatest development in its anterior third, where it is as large as the pars arcuata in cross-section and contains many of the large cells characteristic of the principal portion of the nucleus ventralis (fig. 3). More caudally, it is much narrower and the cells are smaller until, at the caudal pole, it consists almost entirely of intercalated cells in a band ventral to the pars arcuata (figs. 6 to 8). Rostrally, it is continuous with the ventrolateral portion of the pars anterior of the ventral nucleus and is bounded by the latter dorsally and by the pars medialis medially (fig. 2). The pars arcuata lies between these three areas and throughout the remainder of the extent of the pars externa forms the dorsomedial boundary. The medial boundary is formed throughout by the pars medialis, except at the caudal pole, where it is bounded medially by the nucleus subparafascicularis. The nucleus subparafascicularis also forms the medial portion of the caudal boundary (figs. 8 and 9). Laterally, the nucleus is bounded by the external medullary lamina to the level of the anterior pole of the nucleus geniculatus medialis. Caudal to that it is bounded laterally by the intercalated cells in the medial portion of the capsule of the medial geniculate, which, at the caudal pole, extend medially to form the lateral portion of the caudal boundary (fig. 9). Ventrally, it is bounded throughout by the external medullary lamina. Dorsally, the pars anterior bounds the anterior pole. Behind this the sheath of fibers from the pars intermedia of the lateral nucleus extends inward and downward from the lateral margin and separates the pars externa from the caudal pole of the pars anterior (figs. 4 and 5). This sheath extends for a considerable distance into the substance of the pars externa, forming the dorsal boundary in this region. Caudal to the sheath the pars arcuatus extends farther dorsolateralward and forms the remainder of the dorsal boundary of the pars externus. The boundary between the pars externa and the pars arcuata is nowhere sharp. It is differentiated by an indefinite fiber layer between them, by a slight difference in the cellular arrangement (the arrangement in the pars arcuatus being less wave-like, more coarse and irregular, and also, for the most part, more dense), and by a difference in cell structure (the cells of the pars externa being for the most part smaller and more elongated).

The cells of the pars externa are arranged in a course, wave-like reticulum, along fibers running longitudinally and laterally, more or less parallel to the curve of the nucleus, and other fibers running horizontally. In the caudal portion the cells are arranged more as intercalated cells in a capsule. At the anterior pole the cells vary in size from some which are entirely similar to the cells of the pars anterior to small, elongated cells which are, however, of a similar internal structure. Anterior to the sheath of fibers from the pars intermedius of the lateral nucleus, there appears a small group of very large cells (fig. 23, C) at the extreme lateral margin of the nucleus which are as large as any of the cells of the thalamus. They are apparently associated with the fibers running into the nucleus out of the sheath noted above. These cells are rounded polygonal in shape, with deeply staining, diffusely granular cytoplasm. They have several thick, branching, moderately long cytoplasmic processes. The nuclei are small and oval, with a very dense chromatin network and large, single, deeply staining nucleoli. Each nucleus is surrounded by a pale zone free from granulations. The nuclear structure and the pale perinuclear zone are the chief features differentiating these cells from those of the form found in the pars anterior. These large cells are found in the pars externa and the pars arcuata and a few in the nucleus geniculatus medialis, pars magnocellularis, but are not present elsewhere in the thalamus. In the pars externus the cells just anterior to the invading sheath from the lateral nucleus are smaller and more scattered, with a few of the large characteristic cells present especially laterally. Ventral and caudal to the sheath there are many of the large cells, and here the pars externa attains its largest dimensions. There are few medium-sized cells, however, the large cells being scattered in a reticulum of small, elongated cells, and in the ventromedial portion of the nucleus the cells are all of this intercalate type. Caudal to the sheath the pars externus rapidly becomes narrower and the cells smaller, with a few scattered cells of the large type, mostly laterally. Finally, at the caudal end the pars externus lies as a band of small, elongated, intercalated cells ventral to the caudal portion of the pars arcuata. The caudal pole of the pars externa extends for a short distance ventral to the pars commissuralis interventralis, and in this region there is question of the fusing of its cells with those of the nucleus subparafascicularis medially and the cells of the medial portion of the capsule of the internal geniculate laterally, which replace it.

Nucleus ventralis, pars arcuata. This is the main group of the nucleus ventralis. The anterior pole lies at the level of the anterior margin of the internal medullary lamina, bounded rostrally by the pars externa, dorsomedially by the pars medialis, dorsally by the pars anterior, and ventrolaterally by the pars externa. More caudally, the cross-section appears semilunar in form, giving the nucleus its name of 'arcuatus.' It increases in size medially at the expense of the pars medialis and laterally at the expense of the pars externa. The pars medialis forms the medial boundary throughout its extent until it fuses with the pars commissuralis interventralis caudally. The pars medialis also extends as a layer between the dorsomedial portion of the pars arcuatus and the internal medullary lamina at the anterior pole of the latter. This layer rapidly decreases in extent passing caudally, until the pars arcuata reaches the lateral border of the nucleus submedius at about the middle of the latter (fig. 5). The dorsal boundary is formed at first by the pars anterior. A little caudal to the anterior pole it is fused medially at its dorsomedial corner with the anterior pole of the nucleus centralis lateralis, along laterally running fibers, in a manner similar to the fusion of the pars anterior with the latter nucleus (fig. 4). Caudal to this, the pars intermedia of the lateral nucleus extends between the nucleus centralis lateralis and the pars arcuata, and a sheath of fibers from the pars intermedia extends ventrally into the substance of the pars arcuata (figs. 5 and 18). This sheath here forms the dorsal boundary, and behind it a projection of the pars intermedia continues to separate the dorsomedial corner of the pars arcuatus from the internal medullary lamina. With the development of the pars posterior of the lateral nucleus more caudally the latter forms the dorsal boundary of the pars arcuata, also extending along fibers between the dorsomedial corner of the pars arcuata and the internal medullary lamina (figs. 7 and 8). The ventral portion of the pars posterior of the lateral nucleus continues to form the dorsal boundary until it is replaced caudally by the nucleus suprageniculatus. Here the dorsomedial boundary is formed by the internal medullary lamina and the nucleus limitans (fig. 9). At the caudal pole the remaining cells of the pars arcuata apparently fuse with the caudal cells of the nucleus limitans. Medially, the pars arcuatus is bounded throughout by the pars medialis, until that fuses with the pars commissuralis where the pars arcuata becomes continuous with the lateral portion of the pars commissuralis. Ventrally, the pars arcuatus is bounded by the pars externa throughout its extent, until it becomes continuous with the pars commissuralis, where the nucleus subparafascicularis and the medial portion of the capsule of the internal geniculate replace the pars externa ventrally (fig. 9). Laterally, the pars arcuata is bounded by the pars externa until just in front of the anterior pole of the medial geniculate where the pars arcuata extends to the external medullary lamina laterally. The medial geniculate forms the lateral boundary throughout the remainder of the extent of the pars arcuata.

The arrangement of the cells (fig. 23, D) in the pars arcuata is very irregular. There are three main types of elements: 1) cells similar to those in the pars anterior; 2) small and medium-sized cells, which differ from the first only in their size and in that they stain less deeply; 3) large cells, characteristic of the nucleus ventralis, the same as the large cells described for the pars externa. In the anterior pole cells of the first two types are found, forming a coarse, irregular reticulum, more irregular and less wave-like and elongated than in the pars externa. Cells of type 3 appear a little more caudally, apparently in conjunction with the laterally running fibers. Just in front of the sheath from the pars intermedia of the lateral nucleus the pars arcuata is less dense and the cells on the whole are smaller, but with the invasion of the sheath into the pars arcuata there are great numbers of the largest type of cell, especially around the borders of the sheath. Caudal to the sheath, as the pars arcuata becomes more flattened out and horizontal between the ventral portion of the pars posterior of the lateral nucleus above and the external medullary lamina below, the largest cells are found in a horizontal band, just ventral to the lateral nucleus, the medial portion of the pars arcuata consisting of small and medium-sized cells, which tend to line up in horizontally running fibers. More caudally, this medial portion is replaced by the pars commissuralis. The lateral end of the horizontal band of large cells, which becomes continually smaller and narrower toward the caudal pole, is continuous with the nucleus geniculatus medialis, pars magnocellularis. In the pars arcuata of this region there is a predominance of large cells with deeply staining, small nuclei, whereas in the large-celled portion of the medial geniculate there is a predominance of large cells with large, pale nuclei, though both types are present. More caudally, the band of large cells of the caudal pole of the pars arcuata, which is medially continuous with the pars commissuralis, is separated from the internal geniculate by the medial capsular fibers of the latter. In its caudal portions the large cells are irregularly scattered in a fiber layer containing very little ground-substance—which makes the area look pale. The large cells are also smaller in size in the caudal extent of the nucleus than in the anterior and middle portions.

Nucleus ventralis, pars commissuralis (*n. inter-vent.*), together with the lateral portion of the caudal end of the pars arcuata, with which it is continuous, forms the caudal group of the nucleus ventralis. It is trumpet-shaped in form, small medially where it bridges the midline, and large laterally. In sagittal sections it appears almost round, being slightly flattened dorsally by the fibers of the internal medullary lamina which form the dorsal boundary separating it from the nucleus parafascicularis dorsally (figs. 15 and 16). The medial portion consists of scattered cells among commissural fibers across the midline, just caudal to the caudal pole of the nucleus reuniens, with which it fuses rostroventrally (fig. 8). A short distance away from the midline in sagittal sections it appears separated from the nucleus ventralis pars medialis by a fiber layer and by the concentric arrangement of its cells, but in cross-sections no line of demarcation can be made out. Laterally, it increases considerably in size, extending more caudally and more rostrally than the medial portion. It contains larger cells and fuses with the caudal pole of the pars arcuata (fig. 17). The pars externa extends ventral to the pars commissuralis, under its rostral half; the nucleus subparafascicularis and the medial portion of the capsule of the medial geniculate lie caudoventral to it and, together with the lateral fibers of the posterior commissural system, make the caudal boundary (fig. 16).

In cross-sections the arrangement of the cells is as follows. At the midline they are diffusely scattered in fibers, some of which are commissural in type, while others, belonging to the periventricular system, run vertically. Here the cells are very small and intercalate in nature. More laterally, the cells are arranged horizontally and become larger, to the point where they fuse with the cells of the pars arcuatus. In this lateral region there is no definite arrangement to be noted. In sagittal sections the midline area also appears as diffusely scattered cells, but laterally the cells are definitely arranged concentrically, giving the nucleus a characteristic appearance.

On the basis of the descriptions in the literature (Münzer and Wiener, '02; Ramón y Cajal, '11; Nissl, '13; d'Hollander, '13; Gurdjian, '27, and Le Gros Clark, '29), the ventral nucleus of marsupials, insectivores, and rodents is a clearly delimited cell mass, distinctly separable from the lateral nuclear group. It is generally recognized in these forms as the major nucleus of termination of the lemnisci system. In carnivores von Monakow ('95) described a ventral nucleus which he subdivided into four parts: a nucleus ventralis anterior (equivalent to the pars anterior in the dog), a nucleus ventralis b (equivalent to nucleus submedius and the pars medialis of the dog), and nuclei ventralis a and ventralis c (together homologous to the pars arcuata and the pars externa of the dog). Winkler and Potter ('14) recognized several divisions in the ventral nucleus of the cat. It is not possible, however, to compare their subdivisions with those of other observers, since the various portions are not labeled consistently. Papez ('29) did not differentiate clearly between the ventral and lateral nuclear groups in the cat, although he labeled both ventral and lateral nuclei. The ventral part of his lateral nucleus belongs to the ventral nucleus, while the posterior end of his ventral nucleus is a part of the tegmentum of the midbrain.

In primates still further differentiation has been made, emphasis being placed on the transition zone between the ventral and lateral nuclei. All the literature on primates and human includes descriptions of the centre médian of Luys and an arcuate nucleus, or semilunar nucleus of Flechsig. These two structures are well developed only in higher forms. They have not been described in rodents. In carnivores, since von Monakow's statement that his nucleus medialis b was the centre médian of Luys, the confusion regarding the identification of this nucleus has increased, for obviously his nucleus medialis b is very largely equivalent to the nucleus paracentralis, while at least in certain figures the centre médian of Luys, as far as it exists, is located in his nucleus ventralis b.

According to the von Monakow school (von Monakow, '95; Minkowski, '23 and '24), the lateral and ventral nuclei are associated in function, the former being connected only with the leg areas in the cortex, the latter only with the arm areas. These results are not in accord with those obtained by workers with lower mammals or with the current account of the distribution of the ascending lemnisci system.

The geniculate bodies

The geniculate bodies in the dog occupy a position lateral and posterior in relation to the thalamus. They are more highly differentiated than in the cat or in lower forms, but less so than are the homologous structures in primates. Their position is also more dorsal with relation to the thalamus and midbrain than is found in primates. The following nuclear groups may be differentiated: in relation with the optic tract, the nucleus geniculatus lateralis dorsalis and the nucleus geniculatus lateralis ventralis; in relation with the brachium of the inferior colliculus and the lateral fillet, the nucleus geniculatus medialis, pars principalis, and the nucleus geniculatus medialis, pars magnocellularis.

Nucleus geniculatus lateralis dorsalis. The nucleus geniculatus lateralis dorsalis (figs. 7 to 12, 18 and 19) forms the main part of the lateral geniculate and is a large, laminated, well-demarcated structure. It extends along the dorsal part of the lateral surface of the thalamus from the level of the anterior pole of the habenular complex to the level of the anterior pole of the superior colliculus. Medially, it is bounded by the pulvinar (figs. 9 and 10) and, behind that, by the posterior nucleus and the pretectal area (figs. 10 to 12). For the most part it is well demarcated by a fiber capsule, but in the dorsal portion and more marked caudally, there is some intermingling of the cells of the two posterior laminae of the nucleus geniculatus lateralis with the cells of the lateral portions of the pulvinar and the pretectal areas (figs. 11 and 12). The anterior pole is separated from the nucleus reticularis laterally by fibers of the optic radiations, but more caudally, where the optic tract sweeps up to enter the geniculate, it forms the most lateral part of the brain stem. The internal structure of the nucleus geniculatus lateralis dorsalis appears complicated in cross-sections and as though it changed considerably from one level to the next. However, in sagittal sections (fig. 19) it is quite evident that the nucleus consists of four laminae lying one behind the other and forming an upright, S-shaped structure when looked at from the right-hand side of the brain. These laminae are flat at the dorsal pole, semicylindrical at the middle, and semispherical at the ventral pole, and this folding of the laminae one inside the other readily explains the appearance of the nucleus in cross-sections. The two anterior laminae are very similar and may be designated as the laminae principales anterior and posterior. The third lamina may be called the lamina magnocellularis and the fourth the lamina parvocellularis on the basis of their cell structure.

The lamina principalis anterior is bounded rostrally by the fibers of the optic radiations which separate it from the nucleus reticularis and the lateral part of the nucleus lateralis which lie in front. This lamina is the largest in all dimensions of the four laminae of the nucleus geniculatus lateralis dorsalis. The thickness varies from twenty to twenty-five cells at the center of the ventral pole to about ten cells dorsally and peripherally. The cells are densely arranged and are lined up between fibers which run perpendicularly to the surface of the lamina. Due to this arrangement, the cells are cut at different angles in the cross-sections and appear to vary in size in different regions of the nucleus. In sagittal sections, however, the cells are practically all cut through their long axis and appear uniform in size and structure throughout the lamina. There are three types of cells in the lamina principalis anterior: 1) medium-sized cells, which form the greater number and appear to be the principal cell type; 2) large cells, which are rather numerous, scattered irregularly through the lamina and which appear, especially at the ventral and dorsal margins, to be continuous with the cells of the lamina magnocellularis; 3) scattered small cells. The first cell type, or those of medium size, are mostly fusiform, a few being triangular or polygonal, with two to three moderately long, fine, clear cytoplasmic processes. The cytoplasm stains pale blue and contains numerous moderately coarse, diffusely arranged, deeply stained granulations. In many of these cells there is a pale area around the nucleus which has a reddish tinge and a few, scattered, deeply stained granulations. The cellular nucleus is oval with a coarse, well-stained chromatin network, a definite nuclear membrane, and a single, large deeply stained nucleolus. The large cells, or type 2, are as large as any in the thalamus and are polygonal in shape. They have three to five moderately long, clear, fine, branching processes. The cytoplasm is divided into an ectoplasm, containing rather dense, moderately large, deeply stained granulations, and an endoplasm, which has a reddish tinge and only a few, fine granulations. The nuclei are slightly larger than in the medium-sized cells, but are otherwise similar in structure. The small cell of type 3 is fusiform in shape, with one or two cytoplasmic processes, a diffusely granular, rather pale cytoplasm, and a small, oval nucleus with a single nucleolus.

The lamina principalis anterior is everywhere separated from the lamina principalis posterior by a fiber layer, but at its margins it becomes continuous through a rather abrupt transition zone with the laminae magnocellularis and parvocellularis. The lateral portion of its posterior surface is bounded by the lamina magnocellularis, and here, also, there is no dividing fiber layer, the large cells being scattered in almost equal concentration throughout both.

The lamina principalis posterior lies behind the medial two-thirds of the lamina principalis anterior and is broader at its ventral and dorsal poles than in the middle. It is separated from the anterior lamina by a narrow, clear fiber layer, and is laterally and caudally bounded by the lamina magnocellularis. Medially, it is separated from the lamina parvocellularis by fibers. It is almost exactly similar to the lamina principalis anterior in structure, differing in that it is not quite so sharply demarcated, especially dorsolaterally, where it passes over into the lamina magnocellularis through a transition zone, and also that the cells of the dorsal portion are lined up between fibers which run dorsorostrally, rather than perpendicularly to the surface of the lamina (incoming optic). The ventral pole is as thick as the anterior lamina, but the dorsal pole is thinner. The cells are similar to those of the anterior lamina in all respects.

The lamina magnocellularis is a fiber layer containing scattered cells of the same type as the largest cells of the two principal laminae. It forms a well-developed layer behind the lateral part of the lamina principalis anterior and extends for a short distance between it and the lamina principalis posterior at the lateral margin of the latter. It extends as a definite layer also behind the ventral pole of the posterior principal lamina, but is interrupted by the caudodorsal portion of the latter. In the dorsal and especially the dorsomedial part of the nucleus it intermingles, to a considerable extent, with the lamina parvocellularis.

The lamina parvocellularis forms the posterior portion of the nucleus geniculatus lateralis dorsalis. It is well developed at its ventral pole and swings dorsally as a thin layer of cells among the dorsorostrally directed optic fibers, behind and above the other laminae. At its margins it fuses with the lamina principalis anterior through the lamina magnocellularis. Its most medial cells, especially caudally, mix with the cells of the lateral portions of the pretectal area, the pulvinar, and the posterior nucleus, so that at places no sharp boundary lines can be drawn. At the ventral pole the cells are about the size of, and are similar in structure to, the small cells of the principal laminae. Here they are diffusely scattered, polygonal and triangular in shape. Caudally and dorsally, the cells are much smaller, though similar in type, and are lined up along the optic fibers. It is least developed in the dorsal portion, where the cells intermingle with those of the lamina magnocellularis.

Nucleus geniculatus lateralis ventralis. The nucleus geniculatus lateralis ventralis (figs. 9 and 10) is a small mass of cells which appears triangular in sagittal sections, more or less crescentic in cross-sections, lying in a position ventrolaterocaudal to the ventral pole of the nucleus geniculatus lateralis dorsalis. It is bounded dorsally by the latter nucleus, the two being separated by a clear, narrow fiber layer. Laterally, it is bounded by the optic tract, fibers from which swing into and through it. Medially, the dorsal portion is bounded by the dorsal nucleus of the lateral geniculate, the ventral portion by the anterior pole of the medial geniculate, from which it is separated by the capsular fibers of the latter. This ventral portion extends downward medial to the optic tract, between it and the internal geniculate, being ventrally more or less continuous with the remaining cells of the ventral portion of the nucleus reticularis.

The cells are lined up between dorsally running fibers and for the most part are very small, fusiform in shape, with pale, diffusely granular cytoplasm and one to two processes. The cellular nucleus is small, oval, pale, with a rather well-stained chromatin network and a single nucleolus. In the central portion of the nucleus there are a number of larger cells, triangular to polygonal in shape, with two to four moderately long cytoplasmic processes and numerous, diffusely scattered, well-stained, fine granulations in the cytoplasm. The nuclei of these cells are larger, well outlined, with coarse chromatin network and single nucleoli.

Substantia grisea pregeniculata. Scattered in the fibers rostral to the ventral pole of the nucleus geniculatus lateralis dorsalis is an irregular layer of small cells which can nowhere be regarded as a definite structure (figs. 7 to 9). Medially, these cells intermingle with scattered cells of the lateral part of the pulvinar and, ventrally, with the most dorsal cells of the nucleus geniculatus lateralis ventralis. This scattered layer probably represents the substantia grisea pregeniculata. The cells are irregularly arranged among the fibers. They are small, fusiform, and resemble the smaller cells of the nucleus geniculatus lateralis ventralis.

Nucleus geniculatus medialis. The nucleus geniculatus medialis (figs. 8 to 13, 19) is a globular mass of cells in the caudolateral part of the thalamus, tapering to a point rostroventrally. Its anterior pole lies in the extreme lateral corner of the nucleus ventralis at the level of the rostral border of the mammillary bodies. Caudal to this it increases rapidly in size, lying ventral and slightly medial to the nucleus geniculatus lateralis dorsalis, bounded dorsally by the pulvinar and the nucleus posterior, medially by the caudal portion of the nucleus ventralis, ventrally and laterally by the external medullary lamina. It spreads dorsomedially, fusing with and replacing the posterior part of the lateral nucleus, and in this region of transition lie the groups of cells which have been designated as the nucleus suprageniculatus (figs. 9 and 10). At about this level and caudalward it is laterally separated from the optic tract by its own fiber capsule, medially it is bounded by the field of the medial lemniscus, and dorsalward it extends between the nucleus posterior and the pretectal area laterally and the nuclei of the posterior commissure medially (fig. 10). Caudal to the nucleus geniculatus lateralis it forms the lateral portion of the brain stem and extends in this position caudalward to the level of the middle of the superior colliculus, being ventromedially bounded by the brachium of the inferior colliculus and dorsomedially by the deep layers of the superior colliculus (fig. 13).

The nucleus geniculatus medialis consists of two parts, a pars magnocellularis and a pars principalis. The pars magnocellularis (figs. 8 and 9) is continuous with the large-celled layer of the caudal portion of the nucleus ventralis, pars arcuatus, and consists of the same type of cells as does the latter, namely, large cells, some with large, pale nuclei, others with small, rather deeply stained and well-demarcated nuclei. The only noticeable difference between the pars magnocellularis of the medial geniculate and the pars arcuatus of the nucleus ventralis is that in the former the preponderance of the cells have pale nuclei, whereas in the latter the small nuclear type of cell predominates. The pars magnocellularis extends caudally through about two-thirds of the total extent of the medial geniculate, becoming quite large and stretching in a ventrolateral direction so as to form most of the medial portion of the nucleus. The pars principalis at first develops ventrally and laterally to the pars magnocellularis and more caudally extends dorsomedially, so that the pars magnocellularis at first lies in the dorsomedial portion of the medial geniculate (figs. 10 and 11) and more caudally in the ventromedial portion (fig. 12). The cells are irregularly grouped, being separated by rather large fiber bundles, and there is little ground-substance around them.

The pars principalis of the medial geniculate consists of rather densely grouped cells lined up in diagonally running fibers, with considerable ground-substance between them. The cells are larger and more regularly arranged at the center of the group. Peripherally and especially dorsally, they are elongated between dorsomedially running fibers (fig. 10). In the rostral portions of the nucleus this group fuses with the ventral cells of the pars posterior of the lateral nucleus and no sharp line can be drawn between them. Proceeding caudally, the pars principalis extends dorsomedially to replace the pars posterior of the lateral nucleus, the area of fusion of the two forming the nucleus suprageniculatus (fig. 10). The cells of this dorsal portion also intermingle with the cells of the nucleus posterior, which bounds it dorsolaterally. Throughout the rostral portion of the nucleus the ventral cells of the pars principalis are larger than the lateral and dorsal cells, but in the region behind the level of the nucleus geniculatus lateralis dorsalis the mass becomes homogeneous and remains so to the caudal pole.

The cells are medium-sized, polygonal, triangular, and fusiform in shape, with two to four short, thick, branching processes. The cytoplasm stains well and contains rather numerous, irregularly scattered, deeply staining granulations. The cellular nucleus is oval, pale, with a faint chromatin network and a single, deeply stained nucleolus.

The recent reports on optic localization within the lateral geniculate by Minkowski ('20), Brouwer ('23 and '27), Brouwer and Zeeman ('25 and '26), and Putman ('26) contain detailed accounts of the literature concerned with the lateral geniculate, and further consideration will not be given it here. Mention should be made, however, of a description of the lateral geniculate nucleus of the cat by Thuma ('28). This is based on a series of cross-sections and gives a graphic reconstruction showing the various laminae. In the cat the lamina magnocellularis appears only as scattered cells among the fibers behind the second lamina. Consideration of the lateral geniculate from the phylogenetic standpoint, on the basis of the descriptions in the literature, indicates that the development is along the following lines: an increase in the size and lamination of the dorsal part, a decrease in size of the ventral nucleus of the lateral geniculate, and the appearance of the grisea pregeniculata (Vogt, '09, and Friedemann, '12).

Several authors have misidentified the anterior portion of the medial geniculate, confusing it with the posterior nucleus (Münzer and Wiener, '02; Bianchi, '09, and Winkler and Potter, '14, fig. XIII). Very few attempts have been made to analyze the internal structure of the medial geniculate. Among such attempts especial reference is made to the early work of Ramón y Cajal ('11), who divided it into a superior lobe (the dorsal portion of the principal nucleus in the dog) and an inferior lobe consisting of a superficial portion (the ventrolateral part of the principal nucleus) and a deep portion (corresponding to the pars magnocellularis).

The habenular complex

The habenular complex (figs. 7 to 10) consists of the two habenular nuclei, i.e., the nucleus habenularis medialis and the nucleus habenularis lateralis, together with the incoming stria medullaris, the commissura habenularis, and the habenulo-peduncular tract. In the dog and the cat the commissural fibers swing dorsally, forming an arch between the complexes of the two sides in the same manner as in higher mammals.

Nucleus habenularis lateralis. This nucleus forms the lateral portion of the habenular complex (figs. 7 to 9). It consists of a column of cells scattered in the ventral portion of the stria medullaris extending through the posterior half of the thalamus proper. Rostrally, it is bounded by the stria medullaris; caudally, by the fibers of the habenular commissure. The dorsal boundary is irregular and formed by the stria medullaris. Medially lies the nucleus habenularis medialis. The ventral border is convex ventrally and is separated from the nucleus tractus habenulo-peduncularis lateralis by capsular fibers. The caudal pole of the nucleus parataenialis lies lateral to the anterior pole of the nucleus habenularis lateralis. Caudal to this the lateral boundary is formed by capsular fibers separating the nucleus habenularis lateralis from the caudal portion of the nucleus medialis dorsalis and, more caudally, from the nucleus lateralis pars posterior. The caudal pole lies just anterior to the habenular commissure. It is bounded ventrally and laterally by the nuclei of the commissura posterior.

The cells of the nucleus habenularis lateralis are irregularly scattered among the fibers of the stria medullaris. They are mostly small in size, with a few medium-sized cells mainly along the ventral border. At about the middle and extending to the caudal pole the nucleus becomes divided into two parts, one ventral, consisting of medium-sized cells, the other dorsomedial, consisting of small cells, more densely arranged than those of the ventral portion. There is no sharp line of demarcation between these two portions. The dorsomedial, small-celled portion seems to fuse with the lateral margin of the nucleus habenularis medialis. At the caudal pole the two portions of the nucleus habenularis lateralis fuse into one, consisting of scattered small cells. The cells are rounded polygonal to fusiform, with a small amount of cytoplasm containing scattered granulations. They are pale and have two to four short, cytoplasmic processes. The cellular nucleus is large relative to the size of the cell, occupying most of the cross-sectional area. It is round to oval, pale, contains a faint chromatin network and a small, single, deeply stained nucleolus.

Nucleus habenularis medialis. This nucleus forms the medial portion of the habenular complex (figs. 7 to 10). It extends through the posterior half of the thalamus medial to the stria medullaris, the cells of its lateral border lying among the fibers of the latter. In cross-sections it is shaped like an inverted comma. The rostral pole lies a few sections caudal to the rostral pole of the nucleus habenularis lateralis. Dorsally and medially, it is bounded by the floor of the ventricle and adjoins the ependymal cells. Ventrally, it is separated by capsular fibers from the dorsomedial corner of the nucleus medialis dorsalis; more caudally, from the nucleus tractus habenulo-peduncularis medialis, and at the caudal pole, from the nuclei of the commissura posterior. Laterally, it is bounded by the nucleus habenularis lateralis throughout the extent of the latter, fusing with its small-celled dorsal portion. Caudal to the termination of the nucleus habenularis lateralis the lateral border is formed by the fibers of the habenular commissure as they swing dorsally and then medially. The caudal pole extends along the medial border of the arm of the commissure for a short distance.

The neurones are irregularly arranged, very densely packed together, more so ventrally than in the narrower dorsal extension. The cells are about the size of, or a little larger than, the small cells, but smaller than the large cells of the nucleus habenularis lateralis and resemble them in structure, except that, due to crowding, they are more rounded, or fusiform, with less evident cytoplasmic processes and more deeply stained cytoplasm. The cellular nuclei of the two groups are entirely similar.

The habenular complex is one of the most constant formations in the diencephalon through the vertebrate series. The two nuclei have been described in representatives of most vertebrate types, and their size varies in part, but not wholly, with the development of the olfactory system.

Preoptic area

The preoptic area (figs. 1, 2, 15, and 16) properly forms part of the telencephalon, but as it is closely associated, both in position and by its connections, with the hypothalamus, it will be briefly described here. It lies ventral to the thalamus, between the level of the commissura anterior and the chiasma opticum. It may be divided into two parts, medial and lateral. The former comprises the preoptic portion of the periventricular system of fibers, the medial preoptic area, and the bed nucleus of the anterior commissure. The latter includes the nucleus interstitialis pedunculi thalami inferioris, the lateral preoptic area, and the caudal continuation of the medial parolfactory nucleus and of the nucleus of the diagonal band of Broca. This caudal continuation is probably homologous to the substantia innominata of Reichert.

Periventricular system of the preoptic area and the nucleus periventricularis preopticus. The periventricular system in the preoptic area (figs. 1 and 2) is similar in structure and arrangement to the periventricular system of the thalamus and of the hypothalamus, with which it is continuous dorsally and caudally, respectively. It extends rostrally for a short distance as a clear fiber layer along the medial wall of the nucleus parolfactorius medialis. Ventrally, it reaches to the floor of the brain and for a short distance rostral to the chiasma opticum it is continuous with the system of the opposite side under the ventricle. The cells of the system are grouped mainly among the lateral fibers, except in the caudoventral region, where the nucleus periventricularis preopticus borders the ependyma of the ventricle. Laterally, the cells, both of the system in general and of the nucleus, intermingle with the cells of the medial preoptic area and there is no line of demarcation between the two. The cells tend to be larger and to stain more deeply than those of the periventricular system in the dorsal thalamus, but are otherwise similar. This is in keeping with the larger size of the system in the preoptic and hypothalamic regions. The nucleus periventricularis preopticus is situated in the angle between the brain floor and the ventricle wall and extends for a short distance laterally, just in front of the optic chiasm. It forms one of the most definite groups of cells associated with the periventricular fibers.

Medial preoptic area. The medial preoptic area (figs. 1 to 3 and 15) is continuous rostrally with the nucleus striae terminalis medialis and rostrodorsally with the bed nucleus of the anterior commissure. Medially, it fuses with the periventricular system and, laterally, it adjoins the lateral preoptic area. The fornix, with its associated nucleus perifornicalis, descends through the dorsal portion of the area, and the dorsal boundary is here formed by the nucleus filiformis anterior. Caudally, the cells of the area are less densely scattered through the fibers and at the level of the anterior part of the optic chiasm it becomes continuous with the medial hypothalamic area. In sagittal sections a line of demarcation between these two areas can be indefinitely made out (fig. 15). The cells (fig. 24, A) are small and of an undifferentiated type, closely resembling those of the periventricular system. They lie among the fibers in the region, being more densely grouped in the anterodorsal portion of the area and in a zone just lateral to the nucleus periventricularis preopticus.

Bed nucleus of the commissura anterior. This is a group of cells entirely similar to the cells of the medial preoptic area arranged in the fibers immediately around the anterior commissure as it passes through the region between the nuclei of the stria terminalis and the preoptic areas (fig. 15). The nucleus is continuous with the nuclei surrounding it, a differentiation being based only on the direction of the fiber bundles passing through it.

Nucleus interstitialis pedunculi thalami inferioris. This nucleus (figs. 1 to 3) consists of a poorly demarcated group of small cells lying between the fibers of the inferior thalamic peduncle as it enters the ventral margin of the thalamus. Medioventrally, it is more or less continuous with the lateral preoptic area; laterally, as it extends along the fibers of the peduncle through the ventromedial margin of the internal capsule. Its dorsal pole lies between the nucleus hypothalamicus parvocellularis and the medioventral end of the nucleus reticularis and reaches the external medullary lamina dorsally. It is continuous caudally with the dorsal portion of the lateral hypothalamic area. The cells are scattered and poorly defined, with pale cytoplasm and small, pale nuclei. They are fusiform in shape and have one or two processes. Rostrally, the cells are somewhat larger and resemble those of the lateral preoptic area.

Lateral preoptic area. The lateral preoptic area (figs. 1, 2, and 16) lies between the medial preoptic area and the internal capsule, being dorsolaterally bounded by the nucleus interstitialis pedunculi thalami inferioris and ventrolaterally by the ansa lenticularis and the caudal continuation of the medial parolfactory nucleus which lies below the latter. The lateral preoptic area consists of cells scattered in the course of the medial forebrain bundle and forms the bed nucleus of this bundle in the preoptic region. The cells are medium-sized, triangular and star-shaped, appearing irregularly elongated between the fibers. The cytoplasm is pale and diffusely granular, the nuclei small and pale with single, deeply stained nucleoli. Among these there are some larger cells, especially in the zone where this nucleus adjoins the 'substantia innominata of Reichert.' The larger cells are polygonal with several long cytoplasmic processes. The cytoplasm contains numerous coarse, moderately deeply stained granulations. The nuclei are relatively small, round to oval, with fairly well-stained chromatin network and single, small, deeply stained nucleoli. These elements are very similar to those of the nucleus tangentialis and of the nucleus filiformis principalis, and even more closely resemble the larger cells of the 'substantia innominata of Reichert.' The structure of the cells mentioned places them in the general type usually associated with the efferent side of the reflex arc.

Caudal continuation of the medial parolfactory nucleus and of the diagonal band of Broca. In the region under consideration this structure (figs. 1, 2, and 3) appears as a triangular area bounded ventrally by the floor of the brain, dorsomedially by the lateral preoptic area, with which it fuses through a transition zone of crossing fibers, and dorsolaterally by the amygdaloid complex and the cortex of the rhinencephalon. The ansa lenticularis runs horizontally across its dorsal tip. The area is much larger rostrally, where it is continuous, ventral and rostral to the nuclei of the stria terminalis, with the medial parolfactory area. It steadily decreases in size and finally disappears at the level of the optic chiasm. The cells are irregularly scattered among fibers, including those of the diagonal band of Broca, which apparently run between the parolfactory nucleus and the amygdala and rhinencephalic cortex. There are two types of elements, similar to those in the lateral preoptic area, the only difference being that they are somewhat more densely grouped and there are a greater number of the large cells arranged in scattered groups than in the latter area.

Hypothalamus

The hypothalamus extends from the level of the chiasma opticum to the caudal pole of the mammillary bodies (figs. 2 to 10, 15 and 16). It is bounded medially by the ventricle and laterally by the internal capsule and the subthalamus. In thus includes the infundibular and tuber-cinereal regions, which terms have been used by several authors in the nomenclature of the hypothalamic nuclei. The hypothalamus may be divided, in general, into a medial and a lateral area, continuous rostrally with the main divisions of the preoptic area.

It is to be noted that almost no sharp lines of demarcation can be drawn around the hypothalamic nuclei. Their position, for the most part, is indicated by a greater density in the grouping of the cells. Their limits can only be definitely determined by the distribution of specific fiber connections.

Nucleus filiformis anterior. The nucleus filiformis anterior (figs. 1 to 3) is a small, triangular group of cells at the angle between the preoptic area in front, the dorsal thalamus above, and the hypothalamus behind. It is separated from the wall of the ventricle by a thin layer of periventricular fibers and extends laterally for a short distance dorsomedial to the anterior pole of the nucleus perifornicalis. Its caudal pole lies just rostrodorsal to the nucleus filiformis principalis. The cells are irregularly arranged, medium to small in size, and polygonal to fusiform in shape. They have two to four moderately broad, short, branching cytoplasmic processes. The cytoplasm contains rather dense, fine, deeply stained granulations. The nuclei are small, round to oval, fairly well stained, with faint chromatin network and single, deeply staining nucleoli.

Nucleus filiformis principalis. The nucleus filiformis principalis appears as a spearhead directed perpendicularly at the middle of the optic chiasm (figs. 3 and 4). It lies in the lateral portion of the periventricular system, with which it seems to fuse. Ventrally, just above the optic chiasm, it is small and pointed, but increases in size dorsally and just above the nucleus perifornicalis it extends out laterally in the form of scattered cells among a band of fibers which cross the dorsal surface of the hypothalamus and apparently run into the nucleus reticularis. Caudally, the dorsal part of the nucleus filiformis is replaced by the dorsal hypothalamic area. The nucleus filiformis principalis does not fuse with the nucleus filiformis anterior, its dorsal pole being separated from the caudal pole of the latter by scattered cells of the periventricular system. Both structures, however, are fairly well demarcated by their cell type, which differs only in that the cells of the nucleus filiformis principalis (fig. 24, B) are larger and more densely grouped. Ventrally and medially, the nucleus filiformis principalis is intimately fused with the periventricular system, there being no sharp line of demarcation between them.

Nucleus hypothalamicus parvocellularis. This nucleus (figs. 2 to 4 and 15) consists of a small group of cells at the rostrodorsal margin of the hypothalamus, extending for a short distance into the medial part of the preoptic area. It lies between the dorsal thalamus and the hypothalamus, fusing medially with the periventricular system and extending as a band lateralward to the nucleus reticularis. Caudally, it is continuous with the dorsal hypothalamic area. The cells are arranged rather densely along the fibers of the region. They are small, oval to fusiform in shape, with pale, diffusely granular cytoplasm and small processes. The nuclei are small, pale, and clear.

Nucleus ovoideus. The nucleus ovoideus (figs. 3 and 4) is a small group of cells in the angle between the periventricular system and the optic chiasm at the level of the transition from the preoptic to the hypothalamic areas, just behind the level where the nucleus filiformis principalis attains its largest dimensions. It fuses rostromedially with the nucleus periventricularis preopticus, rostrolaterally with the medial preoptic area, laterally and caudolaterally with the anterior hypothalamic area, and its caudal pole extends into the rostral margin of the nucleus supra-opticus diffusus. The cells are similar to those of the medial preoptic area, the nucleus consisting of a condensation of the cells in this position.

Nucleus tangentialis. The nucleus tangentialis (figs. 2 to 6, 15 and 16) is one of the most striking cytological structures in sections taken through the region of the optic chiasm. The main mass of this nucleus consists of a band of cells lying anterior and posterior to the chiasm and optic tract and continued dorsally by scattered cells. It extends lateralward to the lateral margin of the hypothalamus. It is continued caudally by a band of less differentiated cells, scattered along the ventral margin of the lateral hypothalamic area and finally continuous with cells of the lateral mammillary nucleus (figs. 6 to 8). Two or three small groups of similar cells lie scattered in the medial hypothalamic area above the chiasm (figs. 3 and 15).

The cells (fig. 24, C) are large and closely grouped among laterally running fibers. They are triangular to fusiform in outline, with two to three moderately long, fine processes. The cytoplasm contains fine, diffuse, dense granulations out into the processes, so that these appear almost homogeneous and very deeply stained. The nuclei are relatively large, pale, with rather coarse chromatin network.

Nucleus hypothalamicus anterior. The anterior hypothalamic area is continuous rostrally with the medial preoptic area. It is bounded dorsally by the nucleus filiformis, medially by the periventricular system, ventrally by the nucleus supra-opticus diffusus, laterally by the lateral hypothalamic area, and caudally by the nucleus hypothalamicus ventromedialis and nucleus hypothalamicus dorsomedialis (figs. 4 and 15). The nucleus perifornicalis descends with the fornix through its dorsolateral portion. There are no sharp boundary lines. The cells are diffusely arranged and more densely grouped in the ventrolateral portion. The cells are of the same type as those in the medial preoptic area.

Nucleus hypothalamicus ventromedialis. This nucleus (figs. 5, 6, and 15) consists of a condensation of cells in the ventromedial portion of the medial hypothalamic area, bounded rostrally by the anterior hypothalamic area, medially by the periventricular system, ventrally by the nucleus supra-opticus diffusus, and laterally by the nucleus perifornicalis and the nucleus hypothalamicus lateralis. In its medial portion the nucleus hypothalamicus ventromedialis is divided into dorsomedial and ventrolateral condensations of cells (fig. 6), and is closely associated with the nucleus periventricularis ventralis. The cells are similar to those of the medial preoptic area.

Nucleus hypothalamicus dorsomedialis. The nucleus hypothalamicus dorsomedialis (figs. 5, 6, and 15) is a poorly differentiated cellular group in the medial hypothalamic area, lying above the nucleus perifornicalis. It is continuous medially with the nucleus hypothalamicus periventricularis dorsalis and is bounded dorsally by the dorsal hypothalamic area, laterally by the zona incerta and the nucleus hypothalamicus lateralis, and ventrally by the nucleus hypothalamicus ventromedialis and the nucleus perifornicalis. Caudally, it passes into the posterior hypothalamic area without sharp demarcation. The cells are similar to those of the hypothalamic periventricular nuclei.

Dorsal hypothalamic area. The dorsal hypothalamic area (figs. 5, 6, 7, and 15) forms the dorsorostral corner of the medial hypothalamic region. It is continuous rostrally through a transition zone with the nucleus filiformis principalis, laterally with the zona incerta, and fuses ventrally with the nucleus hypothalamicus dorsomedialis. Caudally, it is bounded by the ascending mammillo-thalamic tract, round which the cells are scattered and irregular. The dorsal boundary is formed by the external medullary lamina. The cells of this area are slightly larger and more elongated than those of the other nuclei of the medial hypothalamic group and are lined up in laterally running fibers. This arrangement is most marked caudally.

Nucleus hypothalamicus posterior. This nucleus (figs. 7 and 15) forms the posterior part of the medial hypothalamic area, being bounded in front by the nucleus hypothalamicus dorsomedialis dorsally and the nucleus hypothalamicus ventromedialis ventrally, medially by the periventricular system, and laterally by the zona incerta, the nucleus hypothalamicus lateralis, and the nucleus perifornicalis. The nucleus hypothalamicus ventrolateralis lies ventral and caudal to it. Caudally, the posterior hypothalamic nucleus is bounded by the mammillo-thalamic tract, by the nucleus supramamillaris, and by an area of scattered cells associated with the supramammillary decussation. The cells of this area consist mainly of elements of the type found in the group of medial hypothalamic nuclei, but there is also a layer of scattered, large cells between it and the nucleus hypothalamicus ventromedialis. This layer is continuous with other scattered large cells associated with the nucleus hypothalamicus ventrolateralis, the nucleus supramamillaris, and the nucleus premamillaris. These large cells rather closely resemble those of the nucleus filiformis principalis. (They fall within the nucleus mamillo-infundibularis of Malone, '10 and '14.)

Nucleus hypothalamicus ventrolateralis. The nucleus hypothalamicus ventrolateralis (figs. 7 and 15) consists of a small group of cells situated ventral to the nucleus perifornicalis and just rostral to the mammillary nuclei; its caudal pole extends between the anterior pole of the lateral mammillary nucleus and the periventricular system. It is bounded caudally by a fiber layer and consists of small cells, with scattered large cells among them similar in type to those described above in the nucleus hypothalamicus posterior. The small cells resemble those of the medial preoptic area.

Nucleus perifornicalis. As the descending column of the fornix passes through the medial preoptic and medial hypothalamic areas, it is surrounded by a layer of cells concentrically arranged among fibers. This layer varies from two or three to five or six cells in thickness and is largest in the levels of the optic chiasm (figs. 1 to 7 and 15). It is nowhere sharply demarcated from the surrounding structures. Its cells are similar in type, although slightly larger than those of the region. It is differentiated on the basis of its cellular arrangement.

Nucleus supra-opticus diffusus. This nucleus (figs. 4, 5, and 15) forms the bed nucleus of the supra-optic decussation. It consists of small and scattered cells along the course of the fibers where they pass below the ventricle and it extends laterally as far as the lateral margin of the medial hypothalamic area. It extends caudolaterally with the decussating fibers to the level of the infundibulum. The cells are smaller and less densely grouped than are those of the medial hypothalamic area in general, but are otherwise very similar.

Nucleus hypothalamicus lateralis. This nucleus (figs. 3 to 7 and 16) forms the lateral portion of the hypothalamus, being bounded medially by the medial hypothalamic group of nuclei and laterally by the internal capsule, the cerebral peduncle, and the subthalamus. Rostrally, it is continuous with the lateral preoptic area, in which region it attains its greatest dimensions, and caudally, without sharp demarcation, it passes over into the zona incerta. The cells are arranged along longitudinally and vertically directed fibers of passage. They are small to medium-sized, elongated fusiform in shape, with one to two long, fine processes. The cytoplasm is pale and diffusely granular and the nuclei are small, oval, and pale. Attention should be called to the ventrolateral portion of the lateral hypothalamic nucleus, where the fibers from the ansa lenticularis swing into the hypothalamic region. Here the cells are larger and more nearly triangular in outline, resembling the scattered, large cells noted in the lateral preoptic area. Especially in its ventromedial portion this nucleus forms the bed nucleus for the medial forebrain bundle, and in its dorsolateral portion for the internal thalamic peduncle.

Nucleus supramamillaris. This nucleus (figs. 8 and 9) lies dorsal to the medial mammillary nucleus and forms the bed nucleus of the ventral part of the supramammillary decussation. The rostral portion is situated between the mammillothalamic tract, as it emerges from the mammillary nucleus, and the periventricular system. Caudally, this nucleus becomes continuous with the rostral pole of the interpeduncular nucleus (fig. 10). The cells, in general, are small to medium-sized, fusiform to triangular in shape, with moderately long processes. The cytoplasm contains numerous well-stained granulations, diffusely scattered. The nuclei are round to oval and are pale. This nucleus also contains a group of larger cells lying above the dorsal capsule of the medial mammillary nucleus.

The periventricular system of the hypothalamus. This system (figs. 3 to 9) is continuous with the periventricular system of the preoptic area rostrally and with that of the dorsal thalamus dorsally. Structurally, it does not differ from these, but is somewhat more highly developed. It is continuous with the periventricular system of the opposite side in the region of the supra-optic commissure and again in the region of the supramammillary decussation. There are condensations of cells of the system, forming a dorsal and a ventral nuclear group (fig. 6). In the cross-sections the dorsal and ventral divisions appear at the level of the infundibulum where the former is continuous with the nucleus hypothalamicus dorsomedialis. They increase in size caudally and fuse together, and still farther caudally the cells become scattered. Another condensation occurs just in front of the mammillary nucleus (fig. 7), which represents the nucleus periventricularis hypothalamicus posterior of rodents (Gurdjian, '27).

Nucleus premamillaris; nucleus mamillaris medialis; nucleus mamillaris lateralis. The nucleus premamillaris (figs. 8 and 15) consists of a layer of moderately large cells lying rostral to the ventrolateral margin of the nucleus mamillaris medialis and extending for a short distance caudalward between the medial and lateral mammillary nuclei. The cells are triangular to fusiform in outline, with moderately long processes, and lie close together. The cytoplasm contains diffuse, coarse, well-stained granulations. The cellular nucleus is small, oval, and pale.

The nucleus mamillaris medialis (figs. 8 to 10 and 15) is the main nucleus of the mammillary group and lies behind the infundibulum, extending caudally to the level of the posterior portions of the habenular commissure. This nucleus is bullet-shaped. Rostrally, it is bounded by the nucleus hypothalamicus ventrolateralis and nucleus premamillaris and, dorsally, by the supramammillary commissure. It forms a bilateral eminence on the ventral surface, although the two medial nuclei adjoin each other in the midline. The fornix column can be traced macroscopically to the lateral side of the nucleus (figs. 9 and 15). Even in cell preparations the ventral portion of the supramammillary decussation is seen to receive fibers from the fornix. The nucleus mamillaris medialis appears to be subdivided into several parts, but these subdivisions are due to the distribution of fiber bundles and have no functional significance (fig. 8). The cells of the various parts of the nucleus are similar, being small to medium-sized, globular to triangular in shape, with one to three short processes. The cytoplasm is pale and contains numerous fine granulations, with a few larger scattered granules. The cellular nucleus is relatively large, pale, with a fine chromatin network and a single, deeply stained nucleolus.

The nucleus mamillaris lateralis lies ventrolateral to the nucleus mamillaris medialis and ventral to the fornix column (figs. 8 and 9). Dorsally, it is continuous with the nucleus perifornicalis and, rostrally, with the scattered cells extending forward to the nucleus tangentialis (p. 78). It extends along the brain floor lateralward to the border of the peduncle, where there are a few scattered cells among the ventromedial peduncular fibers. These cells are apparently continuous with the nucleus mamillaris lateralis, on the one hand, and with the substantia nigra, pars reticulata, on the other. The caudal boundary lies at the level of the anterior margin of the substantia nigra, being formed by the scattered cells along the medial border of the pars compacta of this latter area. The cells of the lateral mammillary nucleus are stellate, with long, thick, branching processes. The cytoplasm contains coarse, dense granulations which extend into the processes and stain deeply. The cellular nucleus is large, oval, and pale, with a faint chromatin network and a single, large nucleolus.

The hypothalamic areas show a progressive differentiation from amphibians through reptiles and mammals. This is indicated by a progressive increase, not only in the number of the nuclear masses, but also in the specificity of their fiber relations. Thus Gurdjian ('27) showed that the rodent hypothalamic region was divisible into a considerable group of relatively clear nuclei, definable both on the basis of cell structure and fiber connections. These nuclei, with several additional ones, have been identified in dog. In primates the great development of the subthalamic areas tends to overshadow that of the hypothalamic areas, yet the work of Friedemann ('12) and of Pines ('27) and that of Malone ('10 and '14) on various mammals, including man, indicate that in the highest mammals there is a very considerable nuclear differentiation within the hypothalamic areas.

An attempt to homologize the nuclear groups described for dog with other descriptions in the literature presents various difficulties. The results obtained for dog compare very well with those described by Gurdjian ('27) for rodents. The differences may be summarized as follows: the nucleus ovoideus is much smaller and the medial mammillary nucleus is less differentiated in the dog than in the rat, while the nucleus hypothalamicus parvocellularis and the nucleus hypothalamicus ventrolateralis apparently are present only in the former animal.

In the following table an attempt has been made to homologize the hypothalamic nuclei of the dog with those described for the albino rat by Gurdjian ('27), for the cat by Winkler and Potter ('14), for Cercopithecus by Friedemann ('12), and for human by Malone ('10 and '14). It is to be noted that Malone based his differentiation on cell type, the others on cell groups.

Spiegel and Zweig ('17) described a nucleus perifornicalis in the human; they also identified a nucleus paraventricularis, equivalent to the nucleus filiformis, a nucleus supra-opticus, equivalent to the nucleus tangentialis, and classed the remaining nuclei under the terms of the medial and lateral nuclei of the tuber cinereum. In the rabbit they also described a nucleus suprachiasmaticus, which is apparently equivalent to the nucleus ovoideus.

(DOG)	GURDJIAN	WINKLER AND POTTER	FRIEDEMANN	MALONE
N. filiformis anterior		N. filiformis		
N. filiformis principalis	N. filiformis	N. filiformis	N. paraventricularis hypothalami	N. paraventricularis hypothalami
N. hypothalamicus anterior	N. hypothalamicus anterior	N. infundibularis medialis, in fig. X	Vorderer Kern des Tuber cinereum (includes this with preoptic region t δ	Substantia grisea des dritten Ventrikels, pars inferior
Dorsal hypothalamic area	N. hypothalamicus anterior	N. infundibularis medialis, in fig. X	Vorderer Kern des Tuber cinereum (includes this with preoptic region t δ	
N. ovoideus	N. ovoideus		Ventraler Kern des Tuber cinereum, t γ	Substantia grisea des dritten Ventrikels
N. hypothalamicus parvocellularis		N. hypothalamicus medialis, h.a., in fig. XIA		
N. hypothalamicus ventromedialis	N. hypothalamicus ventromedialis	N. infundibularis medialis, Im, in fig. XI	Ventraler Kern des Tuber cinereum, t γ	Substantia grisea des dritten Ventrikels
N. hypothalamicus dorsomedialis	N. hypothalamicus dorsomedialis	N. infundibularis anterior, Ia, in fig. XI	Dorsaler Kern des Tuber cinereum, t β	Substantia grisea des dritten Ventrikels
N. hypothalamicus posterior	N. hypothalamicus posterior		Dorsaler Kern des Tuber cinereum, t α	Substantia grisea des dritten Ventrikels
N. tangentialis	N. tangentialis	Ganglion opticum basale, Gb op.	N. supra-opticus plus N. anterior pedimenti lateralis	Ganglion opticum basale
N. hypothalamicus lateralis	N. hypothalamicus lateralis	N. infundibularis anterior, Ia, plus N. hypothalamicus lateralis, h.b., in fig. X	N. mamillo-infundibularis plus Regio intermedia pedimenti lateralis	Lateral part of N. tuberomamillaris and of N. tuberis lateralis, plus diencephalic cells of N. ansae peduncularis, in figs. 15, 16 ('14)
N. hypothalamicus periventricularis dorsalis and ventralis	N. hypothalamicus periventricularis anterior	(Shown, but not labeled in figs. X, XI)	Subventriculäre Zone des Tuber cinereum	Substantia grisea des dritten Ventrikels
N. hypothalamicus periventricularis posterior	N. hypothalamicus periventricularis posterior, pars dorsalis	N. infundibularis anterior, Ia, in fig. XII	Subventriculäre Zone des Tuber cinereum	Substantia grisea des dritten Ventrikels

N. hypothalamicus periventricularis posterior	Pars ventralis	N. infundibularis b, Ib, in fig. XII, plus N. infundibularis posterior, Ip, in fig. XIII	Subventriculäre Zone des Tuber cinereum	Substantia grisea des dritten Ventrikels
N. perifornicalis				(Included in) N. tuberomamillaris
N. hypothalamicus ventrolateralis		N. infundibularis medialis, Im, in fig. XII		Substantia grisea des dritten Ventrikels
N. supra-opticus diffusus	N. supra-opticus diffusus		Vorderer Kern des Tuber cinereum, t ϵ	Substantia grisea des dritten Ventrikels
N. supramamillaris	N. premamillaris dorsalis	N. infundibularis posterior, Ip, in fig. XIII		(Included in) N. tuberomamillaris
N. premamillaris	N. premamillaris ventralis			(Included in) N. tuberomamillaris
N. mamillaris medialis	N. mamillaris medialis, pars medianus, pars medialis, pars lateralis, pars commissuralis dorsalis, pars commissuralis ventralis,	Corpus mamillare mediale, dorsal part and ventral part	Corpus mamillare, pars oralis;	Ganglion mediale corporis mamillaris
	pars posterior		pars caudalis	
N. mamillaris lateralis	N. mamillaris lateralis	Corpus mamillare laterale	Few, intensely stained ganglion cells in the Pedimentum laterale, medial part	N. intercalatus ('14). (Included in N. mamillo-infundibularis, '10)
(Represented by dorsal part of N. mamillaris lateralis)			N. intercalatus	N. intercalatus ('10)

DISCUSSION

In comparing the thalamus of the dog and cat with that of other forms described in the literature, certain relations and developments are brought out. In the ascending mammalian scale the direction of the increase in size of the thalamus as a whole has been laterodorsocaudal, due to an increase in importance of certain nuclear groups and a simple displacement, without much change in form or even with retrogressive changes, in other groups. These changes in the form of the thalamus in the different mammalian species are correlated with the increase, decrease, or with the stability of the regions with which it is in connection. The correlations as brought out in the above paper may be summarized as follows:

1. In the dog and cat the anterior nuclear group is well developed and consists of three large, well-differentiated nuclei. This group is represented in all mammalian forms of which accounts are available. As a whole, it varies to a considerable extent with the development of the olfactory, but these olfactory impulses are by no means the only factors concerned with its presence and differentiation.

2. The medial nuclear group, with the exception of certain of its subdivisions, is relatively stable throughout mammalian forms. The changes in the classical medial nucleus appear to be associated with changes in the amount of incoming impulses from body surfaces or viscera (pain, temperature, general sensibility by lemniscus systems, either directly or through the ventral nuclei, and olfactory and other visceral impulses through hypothalamic areas). Thus there is an increase in actual size, but a moderate decrease in proportionate size of the medial nucleus of the dog as compared with that of the rodent. The nucleus centralis lateralis, or magnocellularis, however, is apparently undifferentiated in rodents, becomes highly differentiated in carnivores, shows a decrease in primates, and has not been described in human.

3. The midline group of nuclei attains the peak of its development in lower mammals, such as rodents. Homologous nuclei are recognized in carnivores, with the exceptions

of the rodent nucleus commissuralis intermedialis dorsalis and nucleus commissuralis intersubmedius. The nucleus centralis medialis is the only one of the midline group which shows an increased development in carnivores. There is an interesting difference between the dog and the cat with respect to the nucleus reuniens, this nucleus being much smaller in the former than in the latter animal. The midline group is still less developed in primates and may be entirely absent in man. As these nuclei are associated with the commissural systems of the nuclei of the dorsal thalamus, the changes indicate an increasing independence in function of the two sides in the ascending mammalian scale.

4. It has already been brought out in the discussion of the literature that some of the most marked changes in the phylogenetic development of the thalamus occur in the lateral group of nuclei, apparently associated with their cortical connections. All of the major subdivisions of the lateral nuclear group in primates are definitely represented in carnivores, the further development being in size and intranuclear differentiation, rather than due to the appearance of new nuclei. All these major subdivisions are not clearly represented in marsupials or rodents, the differentiation obviously occurring in some stage between these forms and carnivores. The above discussion does not apply to the pretectal area (nucleus prebigeminus), which is primarily associated with the tectum and progressively decreases in size from lower mammals to primates and has not been described for man.

5. The establishment of homologies of the thalamic nuclei is seldom simple, but of all the nuclear groups the ventral presents most difficulties. On the one hand there is the simple, encapsulated ventral nucleus of rodents, on the other the extensive ventral nucleus of primates, with its specially differentiated anterior portion, and the centre médian of Luys and the semilunar nucleus of Flechsig. Intermediate between these is the ventral nuclear group of carnivores, in which five divisions may be recognized: an anterior, an arcuate, an external, a medial, and a commissural. Without knowing the

details of the distribution of the ascending lemnisci systems on which the nuclear differentiation of the ventral group apparently depends, it is unwise to draw homologies other than to suggest that the centre médian of Luys is represented in the dorsolateral portion of the pars medialis of the carnivore ventral nucleus and the semilunar or arcuate nucleus of Flechsig is roughly comparable to the pars arcuatus.

6. There is rather general agreement that the ventral nucleus of the lateral geniculate is decreasing in size and importance through the ascending mammalian series, while the dorsal nucleus is increasing in size and becoming progressively more highly differentiated. The medial geniculate, though showing some increase in size and differentiation in higher forms, is relatively much more stable than is the dorsal part of the lateral geniculate.

7. The habenular complex in carnivores is directly comparable to that in other vertebrate types.

8. As the hypothalamus is connected with relatively old phylogenetic systems of fibers, it is not surprising that the nuclear pattern of the region in rodents and carnivores is essentially similar. As the analysis of this region depends to a very considerable degree upon the knowledge of the distribution of non-myelinated fibers, a comparison with primates, in which such a study has not been made, is unjustified at this time. It should be reemphasized that the work of Malone on the hypothalamus ('14) is a study of the functional cell types rather than of the functional cell groupings.

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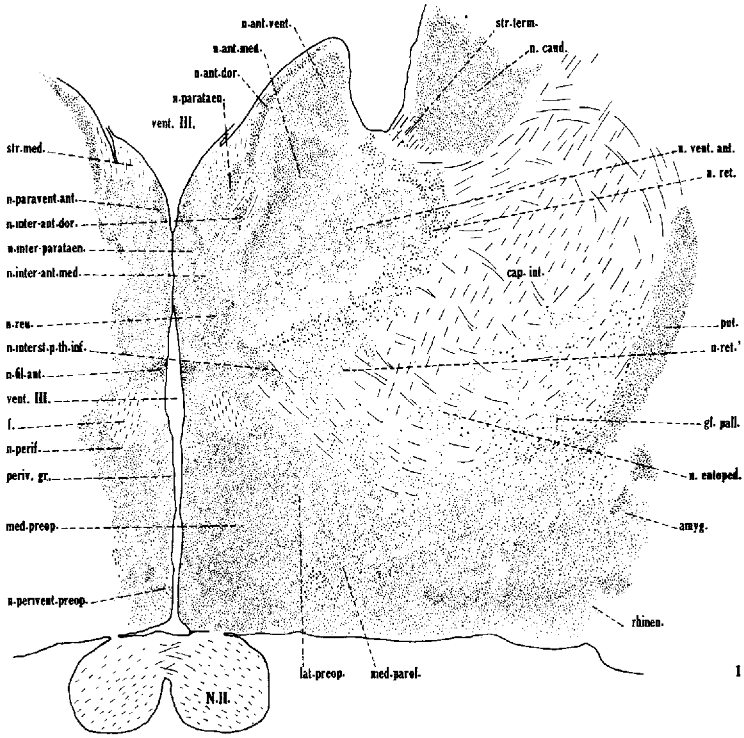
PLATE 1

EXPLANATION OF FIGURES

1 Transverse section through the level of the rostral pole of the nucleus ventralis. Adult dog. Toluidin-blue preparation (1928.317: 1). × 5⅝. *amyg.*, amygdala; *cap.int.*, capsula interna; *f.*, fornix; *gl.pall.*, globus pallidus; *lat. preop.*, lateral preoptic area; *med.parol.*, caudal continuation of medial parolfactory nucleus; *med.preop.*, medial preoptic area; *n.ant.dor.*, nucleus anterodorsalis; *n.ant.med.*, nucleus anteromedialis; *n.ant.vent.*, nucleus anteroventralis; *n.caud.*, nucleus caudatus; *n.entoped.*, nucleus entopeduncularis; *n.fil.ant.*, nucleus filiformis anterior; *n.inter-ant.dor.*, nucleus commissuralis interanterodorsalis; *n.inter-ant.med.*, nucleus commissuralis interanteromedialis; *n.inter-parataen.*, nucleus commissuralis interparataenialis; *n.interst.p.th.inf.*, nucleus interstitialis pedunculi thalami inferioris; *n.parataen.*, nucleus parataenialis; *n.paravent.ant.*, nucleus paraventricularis anterior; *n.perif.*, nucleus perifornicalis; *n.perivent.preop.*, nucleus periventralicularis preopticus; *n.ret.*, nucleus reticularis; *n.ret.'*, nucleus reticularis pars ventralis; *n.reu.*, nucleus reuniens; *n.vent.ant.*, nucleus ventralis, pars anterior; *N.II.*, nervus opticus; *periv.gr.*, periventricular gray; *put.*, putamen; *rhinen.*, rhinencephalon; *str.med.*, stria medullaris; *str.term.*, stria terminalis; *vent.III.*, ventriculus tertius.

2 Transverse section passing through the rostral margin of the optic chiasma. Adult dog. Toluidin-blue preparation (1928.373: 1). × 5⅝. *amyg.*, amygdala; *cap.int.*, capsula interna; *ch.opt.*, chiasma opticum; *f.*, fornix; *gl.pall.*, globus pallidus; *lat.preop.*, lateral preoptic area; *med.parol.*, caudal continuation of the medial parolfactory nucleus; *med.preop.*, medial preoptic area; *n.ant.dor.*, nucleus anterodorsalis; *n.ant.med.*, nucleus anteromedialis; *n.ant.vent.*, nucleus anteroventralis; *n.caud.*, nucleus caudatus; *n.cent.med.*, nucleus centralis medialis; *n.entoped.*, nucleus entopeduncularis; *n.fil.ant.*, nucleus filiformis anterior; *n.hyp. parv.*, nucleus hypothalamicus parvocellularis; *n.inter-ant.dor.*, nucleus commissuralis interanterodorsalis; *n.inter-ant.med.*, nucleus commissuralis interanteromedialis; *n.inter-parataen.*, nucleus interparataenialis; *n.interst.p.th.inf.*, nucleus interstitialis pedunculi thalami inferioris; *n.parataen.*, nucleus parataenialis; *n.paravent.ant.*, nucleus paraventricularis anterior; *n.perif.*, nucleus perifornicalis; *n.perivent.preop.*, nucleus periventricularis preopticus; *n.ret.*, nucleus reticularis; *n.reu.*, nucleus reuniens; *n.tang.*, nucleus tangentialis; *n.vent.ant.*, nucleus ventralis, pars anterior; *n.vent.ext.*, nucleus ventralis, pars externus; *n.vent.med.*, nucleus ventralis, pars medialis; *periv.gr.*, periventricular gray; *put.*, putamen; *rhinen.*, rhinencephalon; *str.med.*, stria medullaris; *str.term.*, stria terminalis; *vent.III.*, ventriculus tertius.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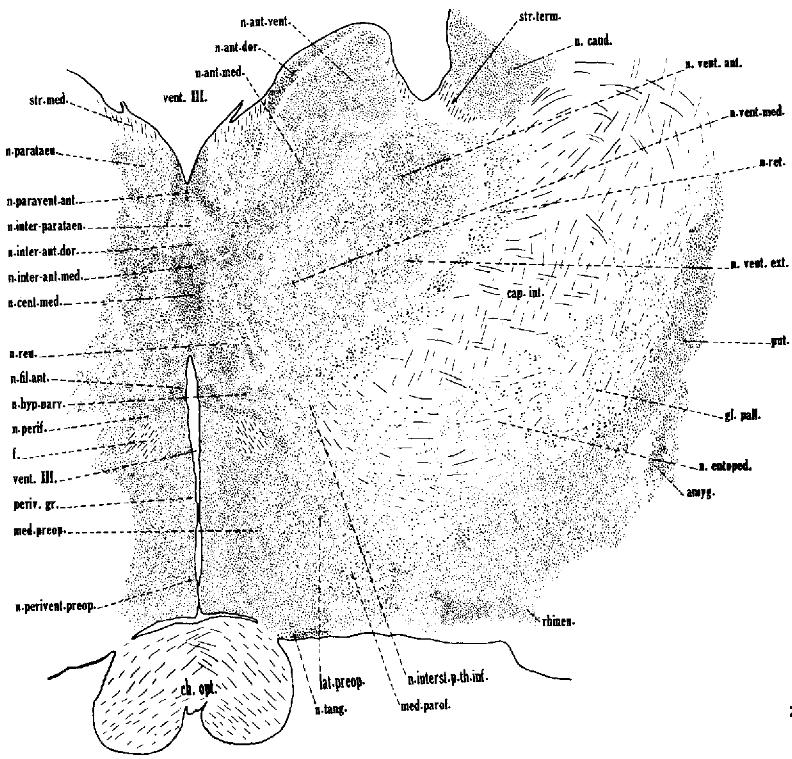
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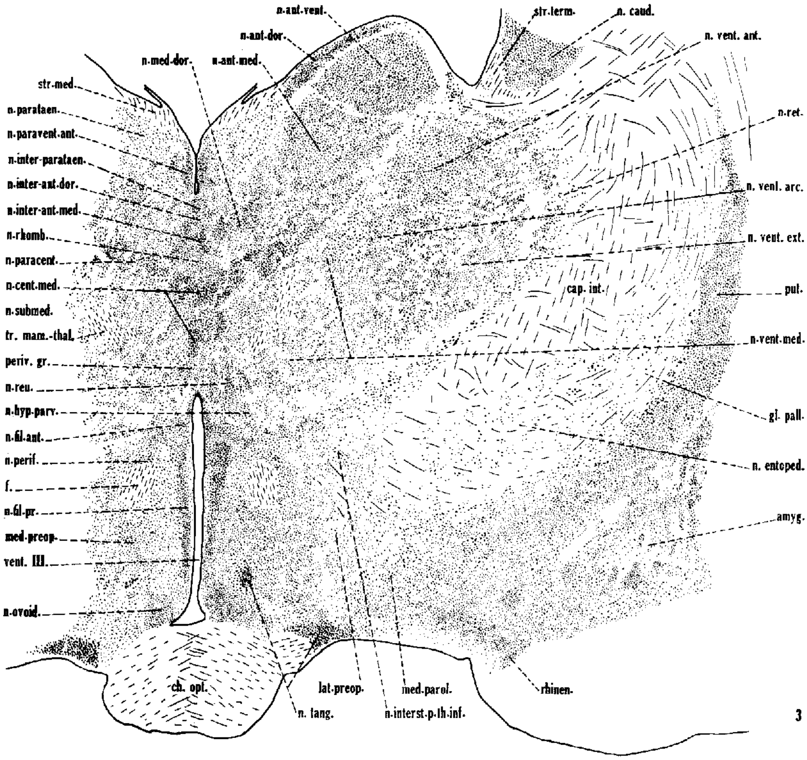
PLATE 2

EXPLANATION OF FIGURES

3 Transverse section through the level of the rostral pole of the nucleus medialis dorsalis. Adult dog. Toluidin-blue preparation (1928.307: 1). $\times 5\frac{2}{3}$. *amyg.*, amygdala; *cap.int.*, capsula interna; *ch.opt.*, chiasma opticum; *f.*, fornix; *gl.pall.*, globus pallidus; *lat.preop.*, lateral preoptic area; *med.preop.*, medial preoptic area; *n.ant.dor.*, nucleus anterodorsalis; *n.ant.med.*, nucleus anteromedialis; *n.ant.vent.*, nucleus anteroventralis; *n.caud.*, nucleus caudatus; *n.cent.med.*, nucleus centralis medialis; *n.entoped.*, nucleus entopeduncularis; *n.fil.ant.*, nucleus filiformis anterior; *n.fil.pr.*, nucleus filiformis principalis; *n.hyp.parv.*, nucleus hypothalamicus parvocellularis; *n.inter-ant.dor.*, nucleus commissuralis interanterodorsalis; *n.inter-ant.med.*, nucleus commissuralis interanteromedialis; *n.inter-parataen.*, nucleus commissuralis interparataenialis; *n.interst.p.th.inf.*, nucleus interstitialis pedunculi thalami inferioris; *n.med.dor.*, nucleus medialis dorsalis; *n.ovoid.*, nucleus ovoideus; *n.paracent.*, nucleus paracentralis; *n.parataen.*, nucleus parataenialis; *n.paravent.ant.*, nucleus paraventricularis anterior; *n.perif.*, nucleus perifornicalis; *n.ret.*, nucleus reticularis; *n.reu.*, nucleus reuniens; *n.rhomb.*, nucleus rhomboidalis; *n.submed.*, nucleus submedius; *n.tang.*, nucleus tangentialis; *n.vent.ant.*, nucleus ventralis, pars anterior; *n.vent.arc.*, nucleus ventralis, pars arcuata; *n.vent.ext.*, nucleus ventralis pars externa; *n.vent.med.*, nucleus ventralis, pars medialis; *periv.gr.*, periventricular gray; *put.*, putamen; *rhinen.*, rhinencephalon; *str.med.*, stria medullaris; *str.term.*, stria terminalis; *tr.mam.thal.*, tractus mamillo-thalamicus; *vent.III.*, ventriculus tertius.

4 Transverse section through the level of the rostral pole of the nucleus lateralis, pars anterior. Adult dog. Toluidin-blue preparation (1928.301: 1). $\times 5\frac{2}{3}$. *amyg.*, amygdala; *cap.int.*, capsula interna; *ch.opt.*, chiasma opticum; *f.*, fornix; *gl.pall.*, globus pallidus; *lat.hyp.*, lateral hypothalamic area; *n.ant.dor.*, nucleus anterodorsalis; *n.ant.med.*, nucleus anteromedialis; *n.ant.vent.*, nucleus anteroventralis; *n.caud.*, nucleus caudatus; *n.cent.lat.*, nucleus centralis lateralis; *n.cent.med.*, nucleus centralis medialis; *n.entoped.*, nucleus entopeduncularis; *n.fil.pr.*, nucleus filiformis principalis; *n.hyp.ant.*, nucleus hypothalamicus anterior; *n.hyp.parv.*, nucleus hypothalamicus parvocellularis; *n.lat.ant.*, nucleus lateralis, pars anterior; *n.med.dor.*, nucleus medialis dorsalis; *n.ovoid.*, nucleus ovoideus; *n.paracent.*, nucleus paracentralis; *n.parataen.*, nucleus parataenialis; *n.paravent. ant.*, nucleus paraventricularis anterior; *n.perif.*, nucleus perifornicalis; *n.ret.*, nucleus reticularis; *n.reu.*, nucleus reuniens; *n.rhomb.*, nucleus rhomboidalis; *n.submed.*, nucleus submedius; *n.supra-opt.dif.*, nucleus supra-opticus diffusus; *n.tang.*, nucleus tangentialis; *n.vent.ant.*, nucleus ventralis, pars anterior; *n.vent. arc.*, nucleus ventralis, pars arcuata; *n.vent.ext.*, nucleus ventralis, pars externa; *n.vent.med.*, nucleus ventralis, pars medialis; *periv.gr.*, periventricular gray; *put.*, putamen; *rhinen.*, rhinencephalon; *str.med.*, stria medullaris; *str.term.*, stria terminalis; *tr.mam.-thal.*, tractus mamillo-thalamicus; *vent.III.*, ventriculus tertius.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n.submed.
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periv. gr.
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n.perif.
f.
n.fil.pr.
med.preop.
vent. III.
n.ovoid.
n.ret.
n. vent. arc.
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cap. int.
put.
n.vent.med.
gl. pall.
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rhinen.
n. tang.
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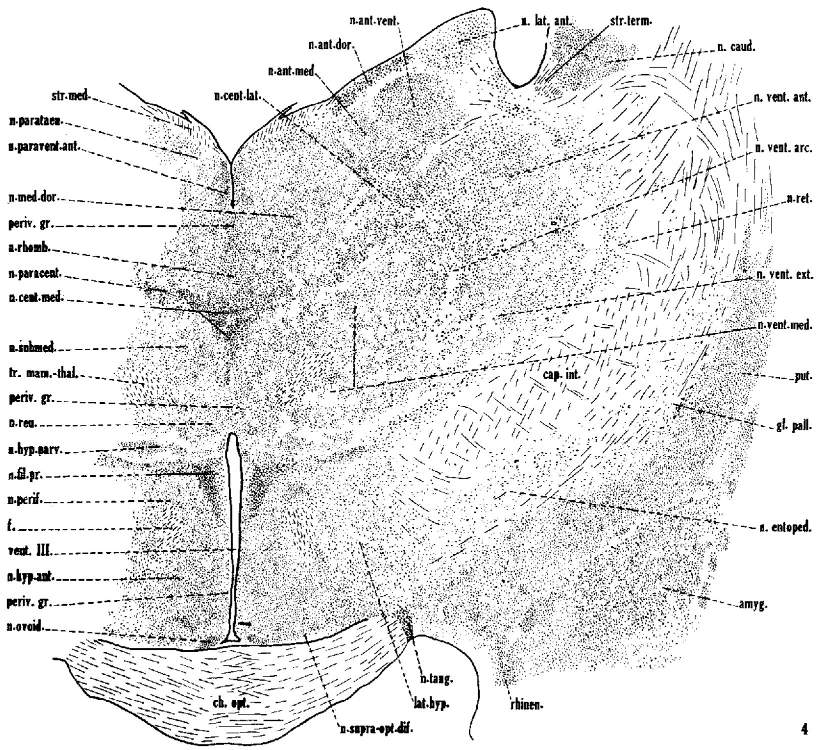
3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periv. gr.
n.rhomb.
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n.submed.
tr. mam.-thal.
cap. int.
put.
periv. gr.
n.reu.
gl. pall.
n.hyp.parv.
n.fil.pr.
n.perif.
f.
n. entoped.
vent. III.
n.hyp.ant.
periv. gr.
amyg.
n.ovoid.
ch. opt.
n.tang.
lat.hyp.
rhinen.
n.supra-opt.dif.

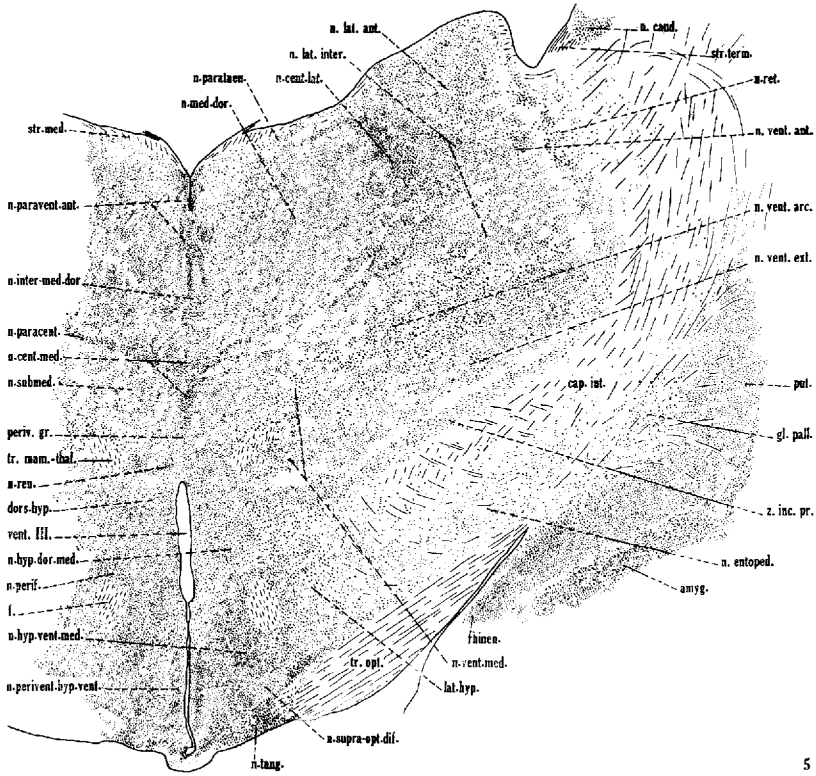
4

PLATE 3

EXPLANATION OF FIGURES

5 Transverse section through the level of the rostral pole of the nucleus lateralis, pars intermedius. Adult dog. Toluidin-blue preparation (1928.288: 1). × $5\frac{3}{5}$. *amyg.*, amygdala; *cap.int.*, capsula interna; *dors.hyp.*, dorsal hypothalamic area; *f.*, fornix; *gl.pall.*, globus pallidus; *lat.hyp.*, lateral hypothalamic area; *n.caud.*, nucleus caudatus; *n.cent.lat.*, nucleus centralis lateralis; *n.cent.med.*, nucleus centralis medialis; *n.entoped.*, nucleus entopeduncularis; *n.hyp.dor.med.*, nucleus hypothalamicus dorsomedialis; *n.hyp.vent.med.*, nucleus hypothalamicus ventromedialis; *n.inter-med.dor.*, nucleus commissuralis intermedialis dorsalis; *n.lat.ant.*, nucleus lateralis, pars anterior; *n.lat.inter.*, nucleus lateralis, pars intermedia; *n.med.dor.*, nucleus medialis dorsalis; *n.paracent.*, nucleus paracentralis; *n.parataen.*, nucleus parataenialis; *n.paravent.ant.*, nucleus paraventricularis anterior; *n.perif.*, nucleus perifornicalis; *n.perivent.hyp.vent.*, nucleus periventricularis hypothalamicus ventralis; *n.reu.*, nucleus reuniens; *n.ret.*, nucleus reticularis; *n.submed.*, nucleus submedius; *n.supra-opt.dif.*, nucleus supra-opticus diffusus; *n.tang.*, nucleus tangentialis; *n.vent.ant.*, nucleus ventralis, pars anterior; *n.vent.arc.*, nucleus ventralis, pars arcuata; *n.vent.ext.*, nucleus ventralis, pars externa; *n.vent.med.*, nucleus ventralis, pars medialis; *periv.gr.*, periventricular gray; *put.*, putamen; *rhinen.*, rhinencephalon; *str.med.*, stria medullaris; *str.term.*, stria terminalis; *tr.mam.-thal.*, tractus mamillo-thalamicus; *tr.opt.*, tractus opticus; *vent.III.*, ventriculus tertius; *z.inc.pr.*, zona incerta proper.

6 Transverse section through the level of the infundibulum. Adult dog. Toluidin-blue preparation (1928.277: 1). × $5\frac{3}{5}$. *amyg.*, amygdala; *cap.int.*, capsula interna; *dors.hyp.*, dorsal hypothalamic area; *f.*, fornix; *gl.pall.*, globus pallidus; *inf.*, infundibulum; *lat.hyp.*, lateral hypothalamic area; *n.cent.lat.*, nucleus centralis lateralis; *n.cent.med.*, nucleus centralis medialis; *n.entoped.*, nucleus entopeduncularis; *n.hyp.dor.med.*, nucleus hypothalamicus dorsomedialis; *n.hyp.vent.med.*, nucleus hypothalamicus ventromedialis; *n.inter-med.dor.*, nucleus commissuralis intermedialis dorsalis; *n.lat.ant.*, nucleus lateralis, pars anterior; *n.lat.inter.*, nucleus lateralis, pars intermedia; *n.lat.post.v.*, nucleus lateralis, pars posterior, portio ventralis; *n.med.dor.*, nucleus medialis dorsalis; *n.paracent.*, nucleus paracentralis; *n.parataen.*, nucleus parataenialis; *n.paravent.ant.*, nucleus paraventricularis anterior; *n.perif.*, nucleus perifornicalis; *n.perivent.hyp.dor.*, nucleus periventricularis hypothalamicus dorsalis; *n.perivent.hyp.vent.*, nucleus periventricularis hypothalamicus ventralis; *n.reu.*, nucleus reuniens; *n.ret.*, nucleus reticularis; *n.submed.*, nucleus submedius; *n.tang.*, nucleus tangentialis; *n.vent. arc.*, nucleus ventralis; pars arcuata; *n.vent.ext.*, nucleus ventralis, pars externa; *n.vent.med.*, nucleus ventralis, pars medialis; *periv.gr.*, periventricular gray; *put.*, putamen; *str.med.*, stria medullaris; *tr.mam.-thal.*, tractus mamillo-thalamicus; *tr.opt.*, tractus opticus; *vent.III.*, ventriculus tertius; *z.inc.pr.*, zona incerta proper.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str. med.
n. vent. ant.
n. paravent. ant.
n. vent. arc.
n. vent. ext.
n. inter-med. dor.
n. paracent.
n. cent. med.
n. submed.
cap. int.
put.
periv. gr.
gl. pall.
tr. mam.-thal.
n. reu.
dors. hyp.
z. inc. pr.
vent. III.
n. hyp. dor. med.
n. entoped.
n. perif.
amyg.
f.
n. hyp. vent. med.
rhinen.
tr. opt.
n. vent. med.
n. perivent. hyp. vent.
lat. hyp.
n. supra-opt. dif.
n. tang.

5


n. lat. inter.
n. lat. ant.
n. lat. post. v.
n. cent. lat.
n. ret.
n. med. dor.
n. parataen.
str. med.
n. paravent. ant.
n. vent. arc.
periv. gr.
n. vent. ext.
n. inter-med. dor
n. paracent.
put.
n. cent. med.
cap. int.
gl. pall.
n. submed.
n. reu.
tr. mam.-thal.
dors. hyp.
vent. III.
amyg.
n. hyp. dor. med.
z. inc. pr.
n. perif.
tr. opt.
f.
n. entoped.
n. perivent. hyp. dor.
n. vent. med.
n. hyp. vent. med.
n. tang.
lat. hyp.
inf.
n. perivent. hyp. vent.

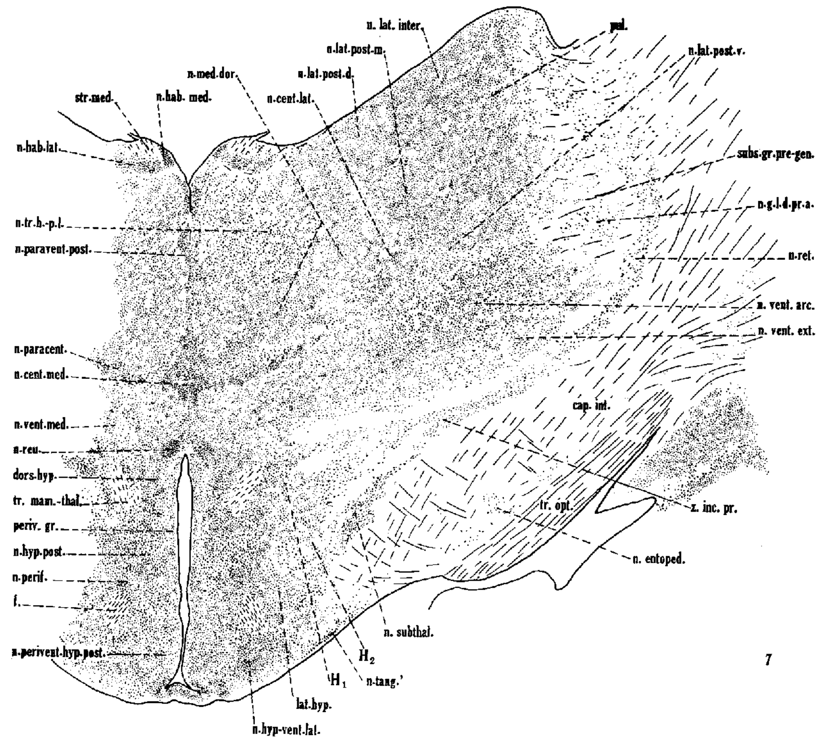
6

PLATE 4

EXPLANATION OF FIGURES

7 Transverse section through the level of the rostral pole of the habenular complex. Adult dog. Toluidin-blue preparation (1928.265: 2). × 5⅔. *cap.int.*, capsula interna; *dors.hyp.*, dorsal hypothalamic area; *f.*, fornix; H_1, field H_1 of Forel; H_2, field H_2 of Forel; *lat.hyp.*, lateral hypothalamic area; *n.cent.lat.*, nucleus centralis lateralis; *n.cent.med.*, nucleus centralis medialis; *n.entoped.*, nucleus entopeduncularis; *n.g.l.d.pr.a.*, nucleus geniculatus lateralis dorsalis, lamina principalis anterior; *n.hab.lat.*, nucleus habenularis lateralis; *n.hab.med.*, nucleus habenularis medialis; *n.hyp.post.*, nucleus hypothalamicus posterior; *n.hyp.vent.lat.*, nucleus hypothalamicus ventrolateralis; *n.lat.inter.*, nucleus lateralis intermedius; *n.lat.post.d.*, nucleus lateralis pars posterior, portio dorsalis; *n.lat.post.m.*, nucleus lateralis pars posterior, portio medialis; *n.lat.post.v.*, nucleus lateralis pars posterior, portio ventralis; *n.med.dor.*, nucleus medialis dorsalis; *n.paracent.*, nucleus paracentralis; *n.paravent.post.*, nucleus paraventricularis posterior; *n.perif.*, nucleus perifornicalis; *n.perivent.hyp.post.*, nucleus periventricularis hypothalamicus posterior; *n.reu.*, nucleus reuniens; *n.ret.*, nucleus reticularis; *n.subthal.*, nucleus subthalamicus; *n.tang.'*, nucleus tangentialis, scattered cells; *n.tr.h.-p.l.*, nucleus tractus habenulo-peduncularis lateralis; *n.vent.arc.*, nucleus ventralis, pars arcuata; *n.vent.ext.*, nucleus ventralis, pars externa; *n.vent.med.*, nucleus ventralis medialis; *periv.gr.*, periventricular gray; *pul.*, pulvinar; *str.med.*, stria medullaris; *subs.gr.pre-gen.*, substantia grisea pregeniculata; *tr.mam.-thal.*, tractus mamillo-thalamicus; *tr.opt.*, tractus opticus; *z.inc.pr.*, zona incerta proper.

8 Transverse section through the level of the rostral pole of the nucleus geniculatus lateralis dorsalis. Adult dog. Toluidin-blue preparation (1928.258: 1). × 5⅔. *a.pretect.*, area pretectalis; *f.*, fornix; H_1, field H_1 of Forel; H_2, field H_2 of Forel; *lat.hyp.*, lateral hypothalamic area; *n.cent.lat.*, nucleus centralis lateralis; *n.cent.med.*, nucleus centralis medialis; *n.entoped.*, nucleus entopeduncularis; *n.g.l.d.parv.*, nucleus geniculatus lateralis dorsalis, lamina parvocellularis; *n.g.l.d.pr.a.*, nucleus geniculatus lateralis dorsalis, lamina principalis anterior; *n.g.l.d.pr.p.*, nucleus geniculatus lateralis dorsalis, lamina principalis posterior; *n.g.m.m.*, nucleus geniculatus medialis, pars magnocellularis; *n.g.m.pr.*, nucleus geniculatus medialis, pars principalis; *n.hab.lat.*, nucleus habenularis lateralis; *n.hab.med.*, nucleus habenularis medialis; *n.hyp.post.*, nucleus hypothalamicus posterior; *n.inter-vent.*, nucleus commissuralis interventralis; *n.lat.post.d.*, nucleus lateralis pars posterior, portio dorsalis; *n.lat.post.m.*, nucleus lateralis pars posterior, portio medialis; *n.lat.post.v.*, nucleus lateralis pars posterior, portio ventralis; *n.mam.lat.*, nucleus mamillaris lateralis; *n.mam.med.*, nucleus mamillaris medialis; *n.med.dor.*, nucleus medialis dorsalis; *n.paraf.*, nucleus parafascicularis; *n.paravent.post.*, nucleus paraventricularis posterior; *n.ret.*, nucleus reticularis; *n.sub-paraf.*, nucleus subparafascicularis; *n.subthal.*, nucleus subthalamicus; *n.supra-mam.*, nucleus supramamillaris; *n.tr.h.-p.l.*, nucleus tractus habenulo-peduncularis lateralis; *n.tr.h.-p.m.*, nucleus tractus habenulo-peduncularis medialis; *n.vent.arc.*, nucleus ventralis, pars arcuata; *n.vent.ext.*, nucleus ventralis, pars externa; *ped.cer.*, pedunculus cerebri; *periv.gr.*, periventricular gray; *pul.*, pulvinar; *str.med.*, stria medullaris; *subs.gr.pre-gen.*, substantia grisea pregeniculata; *tr.mam.-thal.*, tractus mamillo-thalamicus; *tr.opt.*, tractus opticus; *z.inc.pr.*, zona incerta proper.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n.cent.lat.
n.hab.lat.
subs.gr.pre-gen.
n.g.l.d.pr.a.
n.tr.h.-p.l.
n.paravent.post.
n.ret.
n. vent. arc.
n. vent. ext.
n.paracent.
n.cent.med.
cap. int.
n.vent.med.
n.reu.
dors.hyp.
tr. mam.-thal.
periv. gr.
z. inc. pr.
tr. opt.
n.hyp.post.
n. entoped.
n.perif.
f.
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n.perivent.hyp.post.
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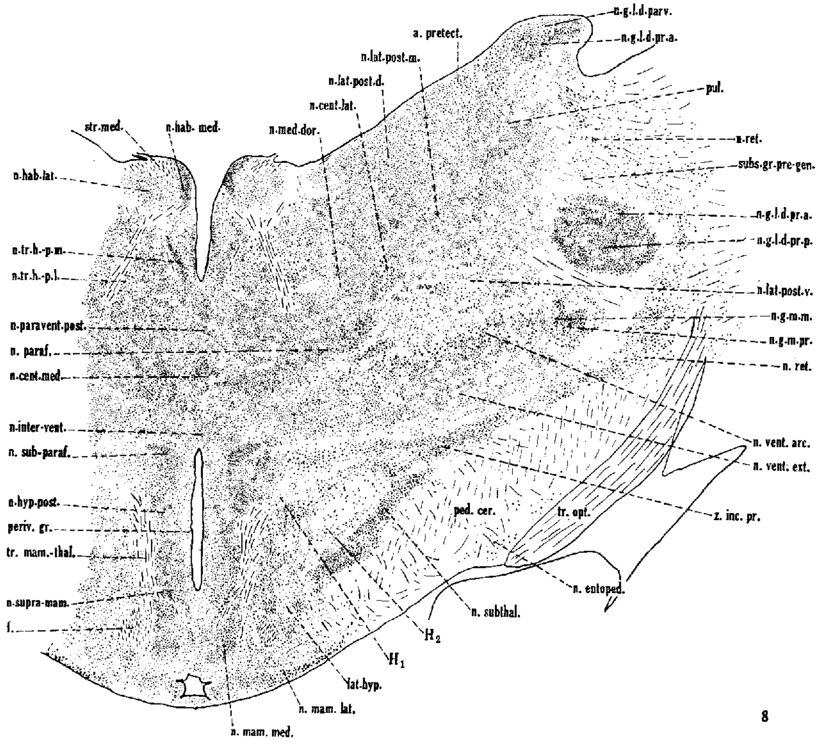
H_1
n.tang.'
lat.hyp.
n.hyp-vent.lat.

7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str.med.
n.hab. med.
n.med.dor.
n.ret.
n.hab.lat.
subs.gr.pre-gen.
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n.paravent.post.
n.g.m.pr.
n. paraf.
n. ret.
n.cent.med.
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n. sub-paraf.
n. vent. ext.
n.hyp.post.
ped. cer.
tr. opt.
z. inc. pr.
periv. gr.
tr. mam.-thal.
n. entoped.
n.supra-mam.
n. subthal.
f.
H_2
H_1
lat.hyp.
n. mam. lat.
n. mam. med.

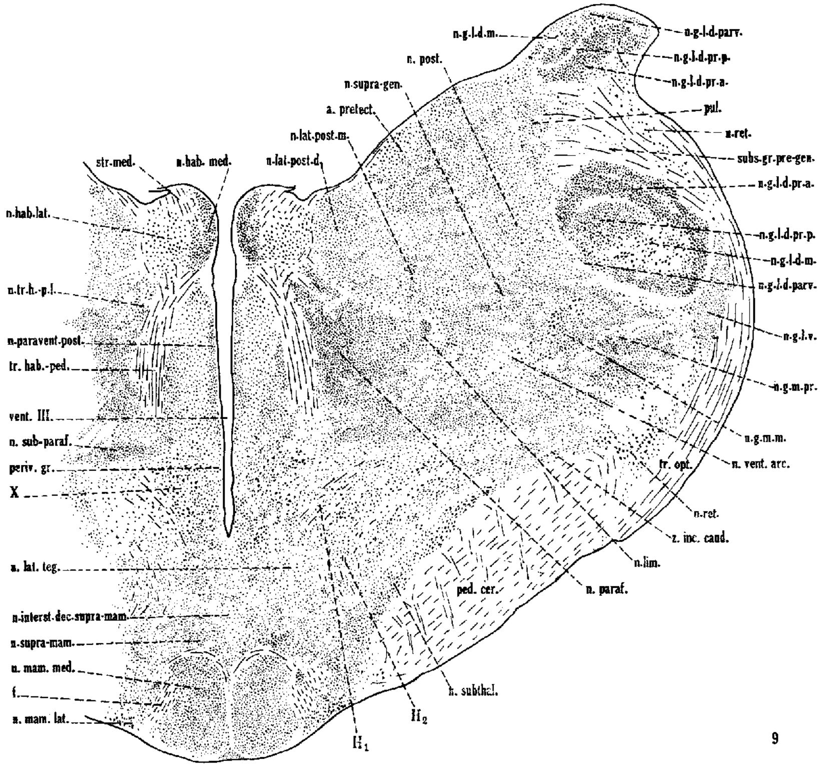
8

PLATE 5

EXPLANATION OF FIGURES

9 Transverse section through the level of the nucleus parafascicularis. Adult dog. Toluidin-blue preparation (1928.248: 1). × 5⅗. *a.pretect.*, area pretectalis; *f.*, fornix; *H_1*, field H_1 of Forel; *H_2*, field H_2 of Forel; *n.g.l.d.m.*, nucleus geniculatus lateralis dorsalis, lamina magnocellularis; *n.g.l.d.parv.*, nucleus geniculatus lateralis dorsalis, lamina parvocellularis; *n.g.l.d.pr.a.*, nucleus geniculatus lateralis dorsalis, lamina principalis anterior; *n.g.l.d.pr.p.*, nucleus geniculatus lateralis dorsalis, lamina principalis posterior; *n.g.l.v.*, nucleus geniculatus lateralis ventralis; *n.g.m.m.*, nucleus geniculatus medialis, pars magnocellularis; *n.g.m.pr.*, nucleus geniculatus medialis, pars principalis; *n.hab.lat.*, nucleus habenularis lateralis; *n.hab.med.*, nucleus habenularis medialis; *n.interst.dec.supra-mam.*, nucleus interstitialis decussationis supramamillaris; *n.lat.post.d.*, nucleus lateralis pars posterior, portio dorsalis; *n.lat.post.m.*, nucleus lateralis pars posterior, portio medialis; *n.lat.teg.*, nucleus lateralis tegmenti; *n.lim.*, nucleus limitans; *n.mam.lat.*, nucleus mamillaris lateralis; ; *n.mam.med.*, nucleus mamillaris medialis; *n.paraf.*, nucleus parafascicularis; *n.paravent.post.*, nucleus paraventricularis posterior; *n.post.*, nucleus posterior; *n.ret.*, nucleus reticularis; *n.sub-paraf.*, nucleus subparafascicularis; *n.subthal.*, nucleus subthalamicus; *n.supra-gen.*, nucleus suprageniculatus; *n.supra-mam.*, nucleus supramamillaris; *n.tr.h.-p.l.*, nucleus tractus habenulo-peduncularis lateralis; *n.vent.arc.*, nucleus ventralis, pars arcuata; *ped.cer.*, pedunculus cerebri; *periv.gr.*, periventricular gray; *pul.*, pulvinar; *str.med.*, stria medullaris; *subs.gr.pre-gen.*, substantia grisea pregeniculata; *tr.hab.-ped.*, tractus habenulo-peduncularis; *tr.opt.*, tractus opticus; *vent.III.*, ventriculus tertius; *X*, cells probably associated with the nucleus interstitialis tegmenti; *z.inc.caud.*, zona incerta caudalis.

10 Transverse section through the level of the habenular commissure. Adult dog. Toluidin-blue preparation (1928.238: 1). × 5⅗. *acq.*, acqueductus; *a.pretect.*, area pretectalis; *com.hab.*, commissura habenularum; *com.post.*, commissura posterior; *H_2*, field H_2 of Forel; *l.m.*, lemniscus medialis; *n.com.post.*, nuclei commissurae posterioris; *n.g.l.d.m.*, nucleus geniculatus lateralis dorsalis, lamina magnocellularis; *n.g.l.d.parv.*, nucleus geniculatus lateralis dorsalis, lamina parvocellularis; *n.g.l.d.pr.a.*, nucleus geniculatus lateralis dorsalis, lamina principalis anterior; *n.g.l.d.pr.p.*, nucleus geniculatus lateralis dorsalis, lamina principalis posterior; *n.g.l.v.*, nucleus geniculatus lateralis ventralis; *n.g.m.m.*, nucleus geniculatus medialis, pars magnocellularis; *n.g.m.pr.*, nucleus geniculatus medialis, pars principalis; *n.hab.med.*, nucleus habenularis medialis; *n.interped.*, nucleus interpeduncularis; *n.interst.dec.supra-mam.*, nucleus interstitialis decussationis supramamillaris; *n.interst.teg.*, nucleus interstitialis tegmenti; *n.lat.post.d.*, nucleus lateralis pars posterior, portio dorsalis; *n.lat.teg.*, nucleus lateralis tegmenti; *n.lim.*, nucleus limitans; *n.mam.med.*, nucleus mamillaris medialis; *n.post.*, nucleus posterior; *n.ret.*, nucleus reticularis; *n.sub-paraf.*, nucleus subparafascicularis; *n.supra-gen.*, nucleus suprageniculatus; *n.vent.arc.*, nucleus ventralis, pars arcuata; *ped.cer.*, pedunculus cerebri; *pul.*, pulvinar; *s.n.comp.*, substantia nigra compacta; *s.n.lat.*, substantia nigra, pars lateralis; *s.n.ret.*, substantia nigra reticularis; *str.gr.cent.*, stratum griseum centrale; *tr.hab.-ped.*, tractus habenulo-peduncularis; *tr.opt.*, tractus opticus; *z.inc.caud.*, zona incerta caudalis.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n.ret.
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subs.gr.pre-gen.
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n.hab.lat.
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periv. gr.
tr. opt.
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a. lat. teg.
n.lim.
ped. cer.
n. paraf.
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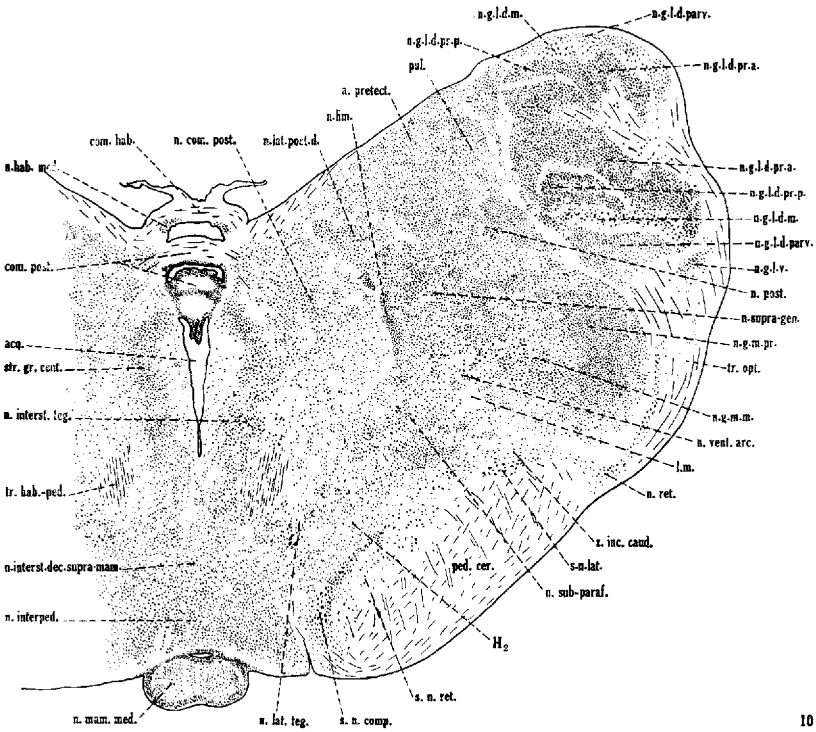
f.
h. subthal.
n. mam. lat.
H_2
H_1

9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n.lim.
com. hab.
n. com. post.
n.lat.post.d.
n.hab. med.
n.g.l.d.pr.a.
n.g.l.d.pr.p.
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n. post.
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n.g.m.pr.
acq.
str. gr. cent.
tr. opt.
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n.g.m.m.
n. vent. arc.
l.m.
tr. hab.-ped.
n. ret.
z. inc. caud.
s.n.lat.
ped. cer.
n.interst.dec.supra-mam.
n. sub-paraf.
n. interped.
H_2
s. n. ret.
n. mam. med.
a. lat. teg.
s. n. comp.

10

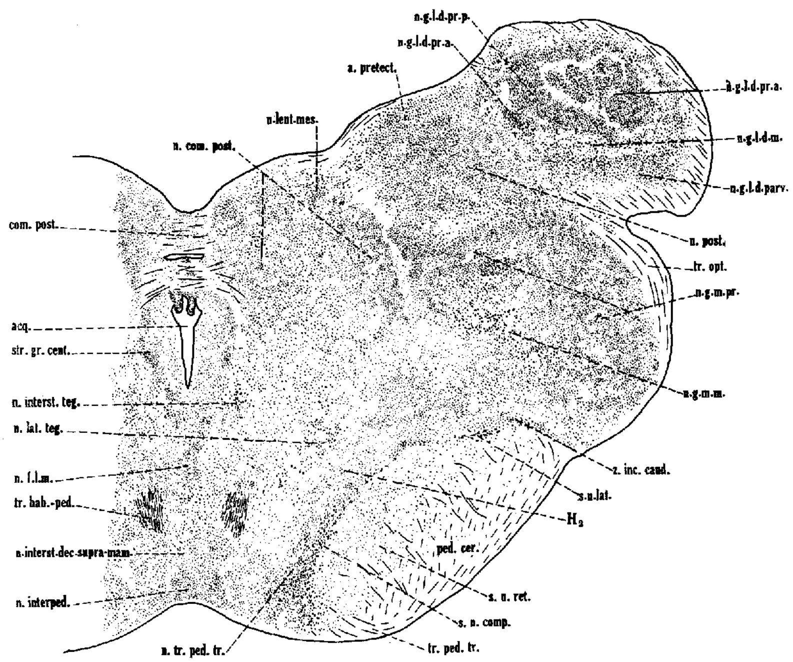
PLATE 6

EXPLANATION OF FIGURES

11 Transverse section through the level of the rostral third of the posterior commissure. Adult dog. Toluidin-blue preparation (1928.229: 1). × 5⅗. *acq.*, acqueductus; *a.pretect.*, area pretectalis; *com.post.*, commissura posterior; *H_2*, field H_2 of Forel; *n.comp.post.*, nuclei commissurae posterioris; *n.f.l.m.*, nucleus fasciculi longitudinalis medialis; *n.g.l.d.m.*, nucleus geniculatus lateralis dorsalis, lamina magnocellularis; *n.g.l.d.parv.*, nucleus geniculatus lateralis dorsalis, lamina parvocellularis; *n.g.l.d.pr.a.*, nucleus geniculatus lateralis dorsalis, lamina principalis anterior; *n.g.l.d.pr.p.*, nucleus geniculatus lateralis dorsalis, lamina principalis posterior; *n.g.m.m.*, nucleus geniculatus medialis, pars magnocellularis; *n.g.m.pr.*, nucleus geniculatus medialis, pars principalis; *n.interped.*, nucleus interpeduncularis; *n.interst.dec.supra-mam.*, nucleus interstitialis decussationis supramamillaris; *n.interst.teg.*, nucleus interstitialis tegmenti; *n.lat.teg.*, nucleus lateralis tegmenti; *n.lent.mes.*, nucleus lenticularis mesencephali; *n.post.*, nucleus posterior; *n.tr.ped.tr.*, nucleus tractus peduncularis transversi; *ped.cer.*, pedunculus cerebri; *s.n.comp.*, substantia nigra compacta; *s.n.lat.*, substantia nigra, pars lateralis; *s.n.ret.*, substantia nigra reticularis; *str.gr.cent.*, stratum griseum centrale; *tr.hab.-ped.*, tractus habenulo-peduncularis; *tr.ped.tr.*, tractus peduncularis transversus; *tr.opt.*, tractus opticus; *z.inc.caud.*, zona incerta caudalis.

12 Transverse section through the root of the oculomotor nerve. Adult dog. Toluidin-blue preparation (1928.221: 1). × 5⅗. *acq.*, acqueductus; *a.pretect.*, area pretectalis; *com.post.*, commissura posterior; *f.l.m.*, fasciculus longitudinalis medialis; *n.com.post.*, nuclei commissurae posterioris; *n.Dark.*,* nucleus of Darkschewitsch; *n.E.-W.*, nucleus of Edinger-Westphal; *n.f.l.m.*, nucleus fasciculi longitudinalis medialis; *n.g.l.d.m.*, nucleus geniculatus lateralis dorsalis, lamina magnocellularis; *n.g.l.d.parv.*, nucleus geniculatus lateralis dorsalis, lamina parvocellularis; *n.g.m.m.*, nucleus geniculatus medialis, pars magnocellularis; *n.g.m.pr.*, nucleus geniculatus medialis, pars principalis; *n.interped.*, nucleus interpeduncularis; *n.interst.teg.*, nucleus interstitialis tegmenti; *n.lat.teg.*, nucleus lateralis tegmenti; *n.lent.mes.*, nucleus lenticularis mesencephali; *n.N.III*, nucleus nervi oculomotorii; *n.N.V.mes.*, nucleus nervi trigemini mesencephalici; *n.post.*, nucleus posterior; *n.rub.*, nucleus ruber; *n.tr.ped.tr.*, nucleus tractus peduncularis transversi; *N.III.*, nervus oculomotorius; *ped.cer.*, pedunculus cerebri; *s.n.comp.*, substantia nigra compacta; *s.n.lat.*, substantia nigra, pars lateralis; *s.n.ret.*, substantia nigra reticularis; *str.gr.cent.*, stratum griseum centrale; *tr.opt.*, tractus opticus; *tr.ped.tr.*, tractus peduncularis transversus.

* Mislabeled, see figure 13.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com. post.
acq.
str. gr. cent.
n. interst. teg.
n. lat. teg.
n. f.l.m.
tr. hab.-ped.
n.interst.dec.supra-mam.
n. interped.
n. tr. ped. tr.
tr. ped. tr.
s. n. comp.
s. n. ret.
ped. cer.
H_2
s.n.lat.
z. inc. caud.
n.g.m.m.
n.g.m.pr.
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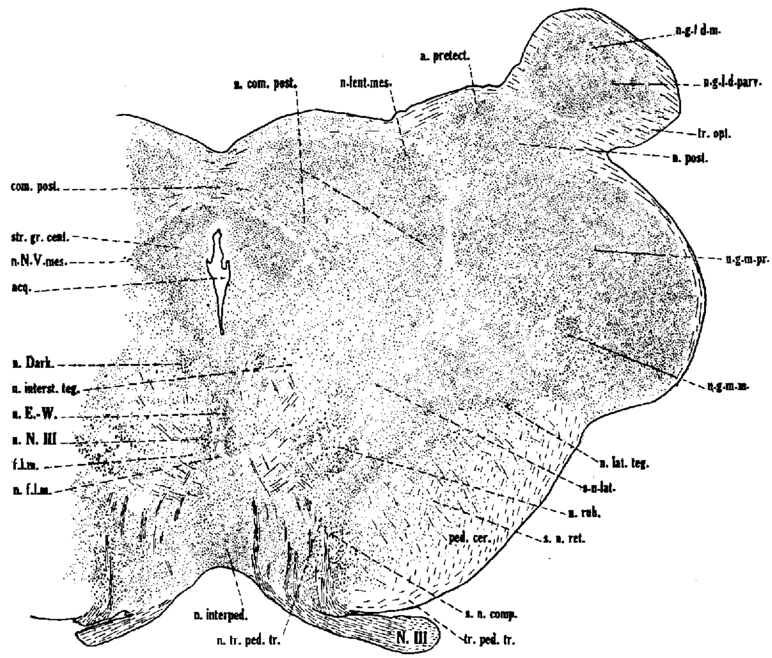
11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tr. opt.
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com. post.
str. gr. cent.
n.N.V.mes.
acq.
n.g.m.pr.
n. Dark.
n. interst. teg.
n. E.-W.
n. N. III
f.l.m.
n. f.l.m.
n.g.m.m.
n. lat. teg.
s.n.lat.
n. rub.
s. n. ret.
ped. cer.
n. interped.
n. tr. ped. tr.
N. III
s. n. comp.
tr. ped. tr.

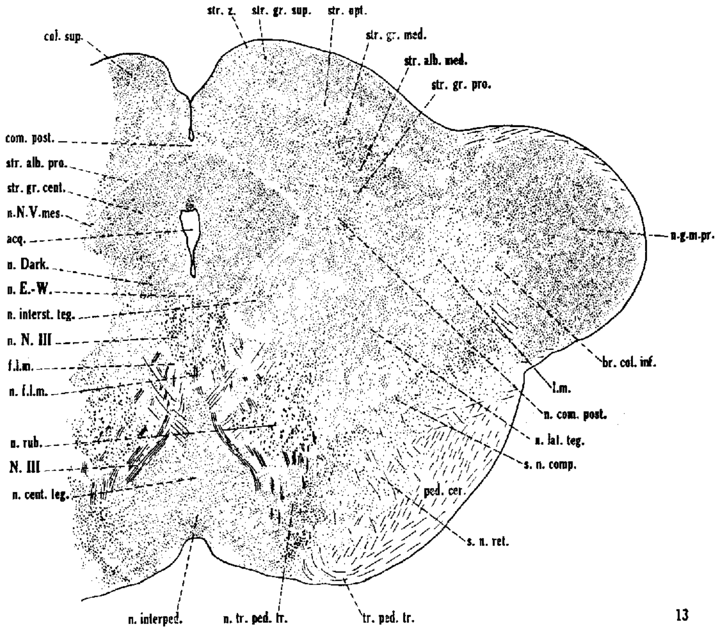
12

PLATE 7

EXPLANATION OF FIGURES

13 Transverse section through the level of the caudal pole of the nucleus geniculatus medialis. Adult dog. Toluidin-blue preparation (1928.210: 1). × 5⅗. *acq.*, acqueductus; *br.col.inf.*, brachium colliculi inferioris; *col.sup.*, colliculus superior; *com.post.*, commissura posterior; *f.l.m.*, fasciculus longitudinalis medialis; *l.m.*, lemniscus medialis; *n.cent.teg.*, nucleus centralis tegmenti; *n.com. post.*, nuclei commissurae posterioris; *n.Dark.*, nucleus of Darkschewitsch; *n.E.-W.*, nucleus of Edinger-Westphal; *n.f.l.m.*, nucleus fasciculi longitudinalis medialis; *n.g.m.pr.*, nucleus geniculatus medialis, pars principalis; *n.interped.*, nucleus interpeduncularis; *n.interst.teg.*, nucleus interstitialis tegmenti; *n.lat.teg.*, nucleus lateralis tegmenti; *n.N.III.*, nucleus nervi oculomotorii; *n.N.V.mes.*, nucleus nervi trigemini mesencephalici; *n.rub.*, nucleus ruber; *n.tr.ped.tr.*, nucleus tractus peduncularis transversi; *N.III.*, nervus oculomotorius; *ped.cer.*, pedunculus cerebri; *s.n.comp.*, substantia nigra compacta; *s.n.ret.*, substantia nigra reticularis; *str. alb.med.*, stratum album mediale; *str.alb.pro.*, stratum album profundum; *str.gr.cent.*, stratum griseum centrale; *str.gr.med.*, stratum griseum mediale; *str. gr.pro.*, stratum griseum profundum; *str.gr.sup.*, stratum griseum superiore; *str.opt.*, stratum opticum; *str.z.*, stratum zonale; *tr.ped.tr.*, tractus peduncularis transversus.

14 Transverse section through the level of the rostral margin of the pons. Adult dog. Toluidin-blue preparation (1928.183: 1). × 5⅗. *acq.*, acqueductus; *br.col.inf.*, brachium colliculi inferioris; *com.col.sup.*, commissura colliculi superioris; *dec.ped.cer.sup.*, decussatio pedunculi cerebelli superioris; *f.l.m.*, fasciculus longitudinalis medialis; *l.l.*, lemniscus lateralis; *l.m.*, lemniscus medialis; *n.cent.teg.*, nucleus centralis tegmenti; *n.f.l.m.*, nucleus fasciculi longitudinalis medialis; *n.interped.*, nucleus interpeduncularis; *n.lat.teg.*, nucleus lateralis tegmenti; *n.l.l.*, nucleus lemnisci lateralis; *n.N.IV*, nucleus nervi trochlearis; *n.N.V. mes.*, nucleus nervi trigemini mesencephalici; *n.pont.lat.*, nucleus pontis lateralis; *ped.cer.*, pedunculus cerebri; *pons*, pons; *s.n.comp.*, substantia nigra compacta; *str.alb.med.*, stratum album mediale; *str.alb.pro.*, stratum album profundum; *str.gr.cent.*, stratum griseum centrale; *str.gr.med.*, stratum griseum mediale; *str.gr.pro.*, stratum griseum profundum; *str.gr.sup.*, stratum griseum superiore; *str.opt.*, stratum opticum; *str.z.*, stratum zonale; *tr.rub.-sp.*, tractus rubro-spinalis.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str. gr. cent.
n.N.V.mes.
acq.
n. Dark.
n. E.-W.
n. interst. teg.
n. N. III
f.l.m.
n. f.l.m.
n. rub.
N. III
n. cent. teg.
n.g.m.pr.
br. col. inf.
l.m.
n. com. post.
n. lat. teg.
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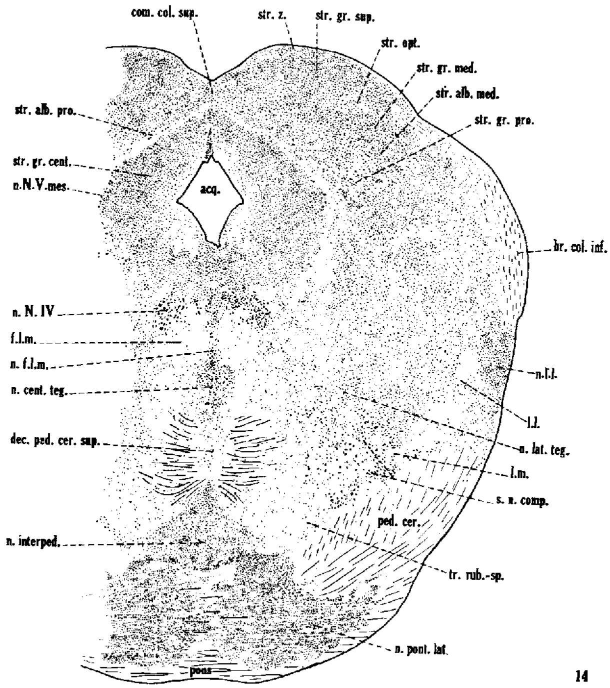
ped. cer.
s. n. ret.
n. interped.
n. tr. ped. tr.
tr. ped. tr.

13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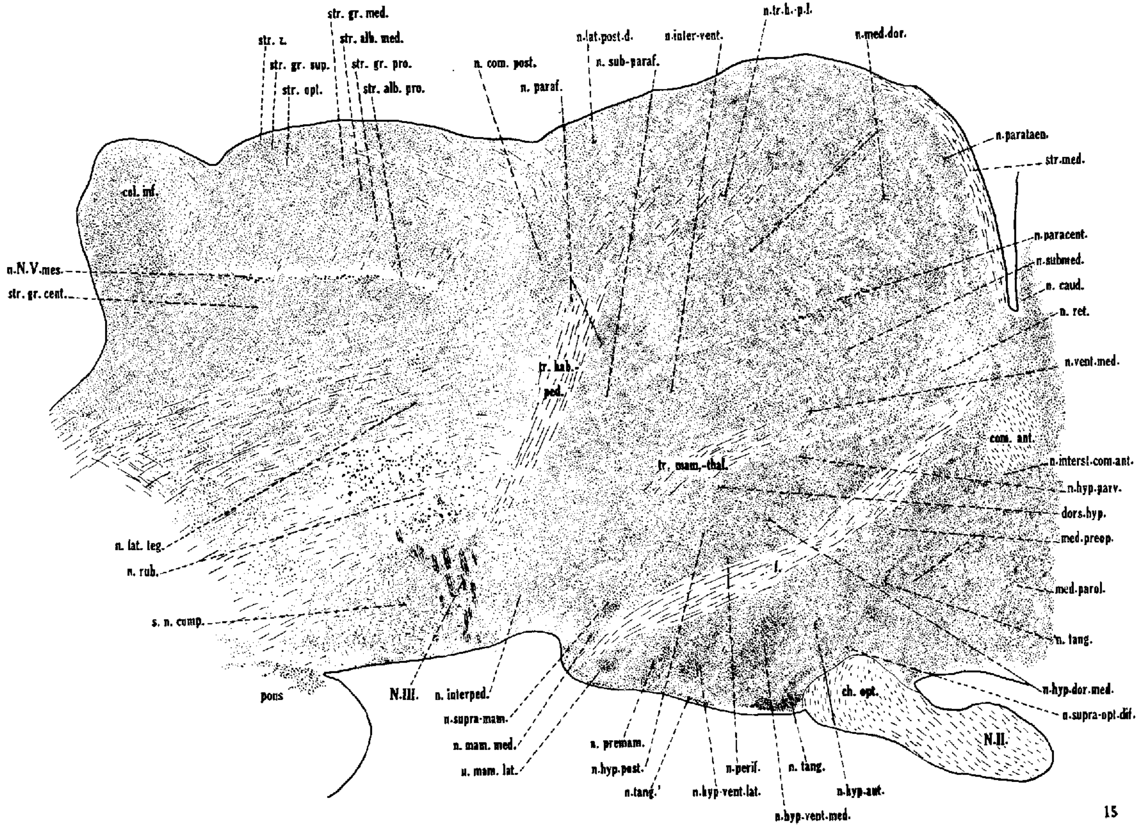
str. gr. pro.
str. alb. pro.
str. gr. cent.
n.N.V.mes.
acq.
br. col. inf.
n. N. IV
f.l.m.
n. f.l.m.
n. cent. teg.
n.l.l.
l.l.
dec. ped. cer. sup.
n. lat. teg.
l.m.
s. n. comp.
ped. cer.
n. interped.
tr. rub.-sp.
n. pont. lat.
pons

14

PLATE 8

EXPLANATION OF FIGURE

15 Sagittal section passing through the tractus habenulo-peduncularis. Adult dog. Toluidin-blue preparation (1928.150). $\times 5\frac{1}{3}$. *ch.opt.*, chiasma opticum; *col.inf.*, colliculus inferior; *com.ant.*, commissura anterior; *dors.hyp.*, dorsal hypothalamic area; *f.*, fornix; *med.parol.*, caudal continuation of medial parolfactory nucleus; *med.preop.*, medial preoptic area; *n.caud.*, nucleus caudatus; *n.com.post.*, nuclei commissurae posterioris; *n.hyp.ant.*, nucleus hypothalamicus anterior; *n.hyp.dor.med.*, nucleus hypothalamicus dorsomedialis; *n.hyp.parv.*, nucleus hypothalamicus parvocellularis; *n.hyp.post.*, nucleus hypothalamicus posterior; *n.hyp.-vent.lat.*, nucleus hypothalamicus ventrolateralis; *n.hyp.vent.med.*, nucleus hypothalamicus ventromedialis; *n.interped.*, nucleus interpeduncularis; *n.interst.com.ant.*, nucleus interstitialis commissurae anterioris; *n.inter-vent.*, nucleus commissuralis interventralis; *n.lat.post.d.*, nucleus lateralis pars posterior, portio dorsalis; *n.lat.teg.*, nucleus lateralis tegmenti; *n.mam.lat.*, nucleus mamillaris lateralis; *n.mam.med.*, nucleus mamillaris medialis; *n.med.dor.*, nucleus medialis dorsalis; *n.N.V.mes.*, nucleus nervi trigemini mesencephalici; *n.paracent.*, nucleus paracentralis; *n.paraf.*, nucleus parafascicularis; *n.parataen.*, nucleus parataenialis; *n.perif.*, nucleus perifornicalis; *n.premam.*, nucleus premamillaris; *n.ret.*, nucleus reticularis; *n.rub.*, nucleus ruber; *n.submed.*, nucleus submedius; *n.sub-paraf.*, nucleus subparafascicularis; *n.supra-mam.*, nucleus supramamillaris; *n.supra-opt.dif.*, nucleus supra-opticus diffusus; *n.tang.*, nucleus tangentialis; *n.tang.'*, nucleus tangentialis, scattered cells; *n.tr.h.-p.l.*, nucleus tractus habenulo-peduncularis lateralis; *n.vent.med.*, nucleus ventralis medialis; *N.II.*, nervus opticus; *N.III.*, nervus oculomotorius; *pons*, pons; *s.n.comp.*, substantia nigra compacta; *str.alb.med.*, stratum album mediale; *str.alb.pro.*, stratum album profundum; *str.gr.cent.*, stratum griseum centrale; *str.gr.med.*, stratum griseum mediale; *str.gr.pro.*, stratum griseum profundum; *str.gr.sup.*, stratum griseum superiore; *str.med.*, stria medullaris; *str.opt.*, stratum opticum; *str.z.*, stratum zonale; *tr.hab.-ped.*, tractus habenulo-peduncularis; *tr.mam.-thal.*, tractus mamillo-thalamicus.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str. alb. med.
str. gr. pro.
str. alb. pro.
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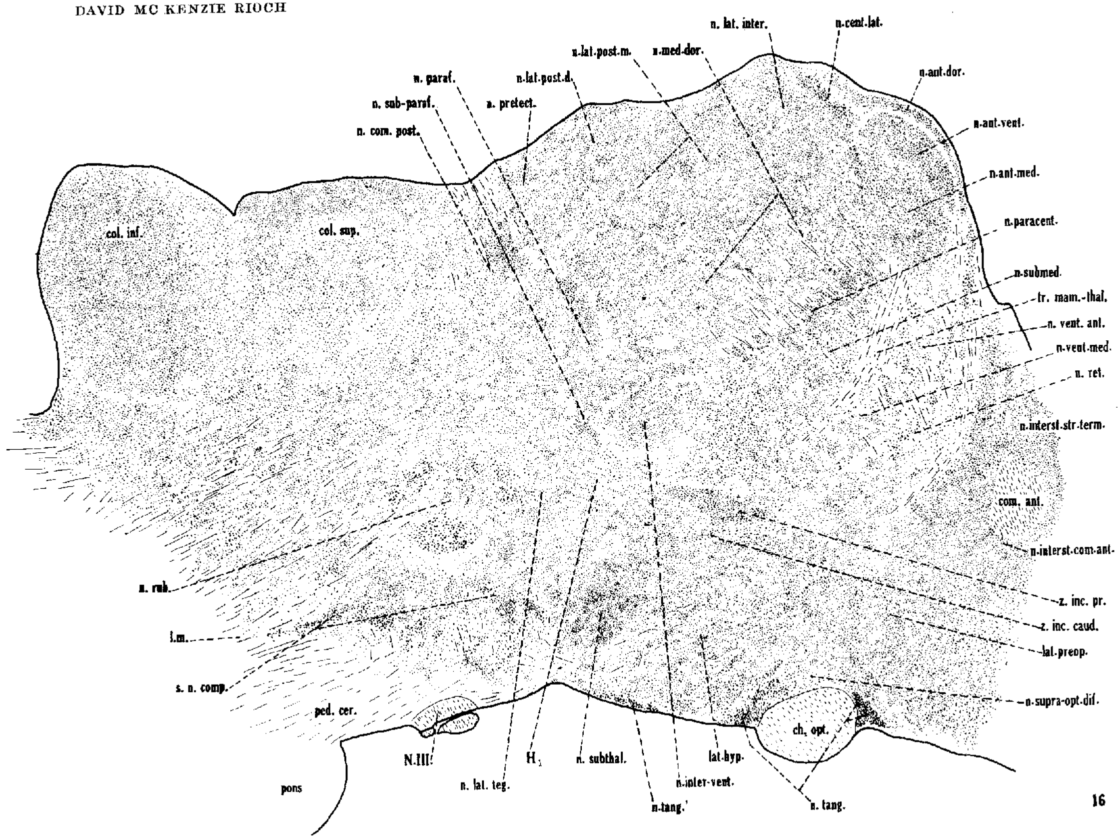
n.lat.post.d.
n. sub-paraf.
n.inter-vent.
n.tr.h.-p.l.
n.med.dor.
n.parataen.
str.med.
n.paracent.
n.submed.
n. caud.
n. ret.
n.vent.med.
col. inf.
n.N.V.mes.
str. gr. cent.
tr. hab.-ped.
com. ant.
n.interst.com.ant.
n.hyp.parv.
dors.hyp.
med.preop.
med.parol.
n. tang.
tr. mam.-thal.
n. lat. teg.
n. rub.
s. n. comp.
pons
N.III.
n. interped.
n.supra-mam.
n. mam. med.
n. mam. lat.
n. premam.
n.hyp.post.
n.tang.'
n.hyp-vent.lat.
n.peril.
n.hyp-vent.med.
n. tang.
n.hyp.ant.
ch. opt.
N.II.
n.hyp.dor.med.
n.supra-opt-dif.

15

PLATE 9

EXPLANATION OF FIGURE

16 Sagittal section passing through the nucleus ruber. Adult dog. Toluidin-blue preparation (1928.128). $\times 5\frac{2}{3}$. *a.pretect.*, area pretectalis; *ch.opt.*, chiasma opticum; *col.inf.*, colliculus inferior; *col.sup.*, colliculus superior; *com.ant.*, commissura anterior; H_1, field H_1 of Forel; *lat.hyp.*, lateral hypothalamic area; *lat.preop.*, lateral preoptic area; *l.m.*, lemniscus medialis; *n.ant.dor.* nucleus anterodorsalis; *n.ant.med.*, nucleus anteromedialis; *n.ant.vent.*, nucleus anteroventralis; *n.cent.lat.*, nucleus centralis lateralis; *n.com.post.*, nuclei commissurae posterioris; *n.interst.com.ant.*, nucleus interstitialis commissurae anterioris; *n.interst. str.term.*, nucleus interstitialis stria terminalis; *n.inter-vent.*, nucleus commissuralis interventralis; *n.lat.inter.*, nucleus lateralis intermedius; *n.lat.post.d.*, nucleus lateralis pars posterior, portio dorsalis; *n.lat.post.m.*, nucleus lateralis pars posterior, portio medialis; *n.lat.teg.*, nucleus lateralis tegmenti; *n.med.dor.*, nucleus medialis dorsalis; *n.paracent.*, nucleus paracentralis; *n.paraf.*, nucleus parafascicularis; *n.ret.*, nucleus reticularis; *n.rub.*, nucleus ruber; *n.submed.*, nucleus submedius; *n.sub-paraf.*, nucleus subparafascicularis; *n.subthal.*, nucleus subthalamicus; *n.supra-opt.dif.*, nucleus supra-opticus diffusus; *n.tang.*, nucleus tangentialis; *n.tang.'*, nucleus tangentialis, scattered cells; *n.vent.ant.*, nucleus ventralis, pars anterior; *n.vent.med.*, nucleus ventralis medialis; *N.III.*, nervus oculomotorius; *ped.cer.*, pedunculus cerebri; *pons*, pons; *s.n.comp.*, substantia nigra compacta; *tr.mam.-thal.*, tractus mamillo-thalamicus; *z.inc.caud.*, zona incerta caudalis; *z.inc. pr.*, zona incerta proper.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n.med.dor.
n.ant.dor.
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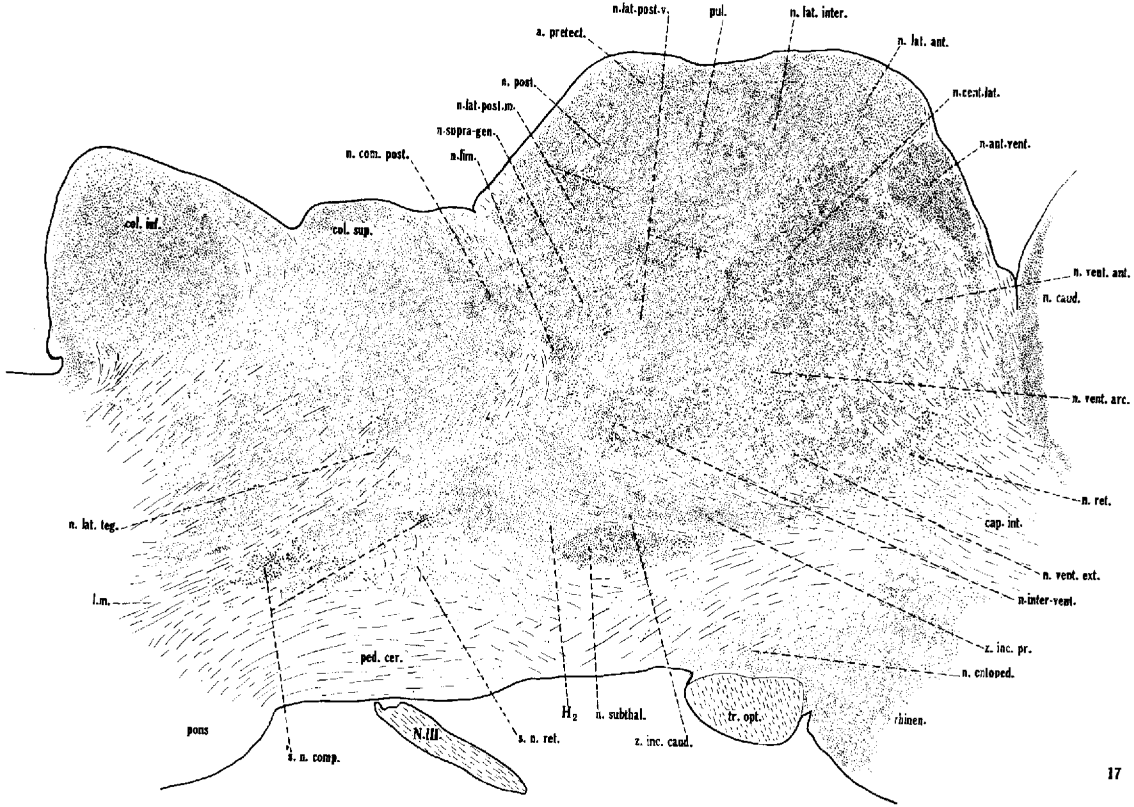
n.lat.post.d.
n. sub-paraf.
n. pretect.
n.ant.vent.
n. com. post.
n.ant.med.
col. inf.
col. sup.
n.paracent.
n.submed.
tr. mam.-thal.
n. vent. ant.
n.vent.med.
n. ret.
n.interst.str.term.
com. ant.
n.interst.com.ant.
n. rub.
z. inc. pr.
z. inc. caud.
l.m.
lat.preop.
s. n. comp.
n.supra-opt.dif.
ped. cer.
ch. opt.
N.III
H
n. subthal.
lat.hyp.
pons
n. lat. teg.
n.inter-vent.
n.tang.'
n. tang.
16

PLATE 10.

EXPLANATION OF FIGURE

17 Sagittal section passing through the main mass of the nucleus centralis lateralis. Adult dog. Toluidin-blue preparation (1928.98). × $5\frac{2}{3}$. *a.pretect.*, area pretectalis; *cap.int.*, capsula interna; *col.inf.*, colliculus inferior; *col. sup.*, colliculus superior; H_2, field H_2 of Forel; *l.m.*, lemniscus medialis; *n.ant.vent.*, nucleus anteroventralis; *n.caud.*, nucleus caudatus; *n.cent.lat.*, nucleus centralis lateralis; *n.com.post.*, nuclei commissurae posterioris; *n.entoped.*, nucleus entopeduncularis; *n.inter-vent.*, nucleus commissuralis interventralis; *n.lat.ant.*, nucleus lateralis anterior; *n.lat.inter.*, nucleus lateralis intermedius; *n.lat.post.m.*, nucleus lateralis pars posterior, portio medialis; *n.lat.post.v.*, nucleus lateralis pars posterior, portio ventralis; *n.lat.teg.*, nucleus lateralis tegmenti; *n.lim.*, nucleus limitans; *n.post.*, nucleus posterior; *n.ret.*, nucleus reticularis; *n.subthal.*, nucleus subthalamicus; *n.supra-gen.*, nucleus suprageniculatus; *n.vent.ant.*, nucleus ventralis, pars anterior; *n.vent.arc.*, nucleus ventralis, pars arcuata; *n.vent.ext.*, nucleus ventralis, pars externus; *N.III.*, nervus oculomotorius; *ped.cer.*, pedunculus cerebri; *pons*, pons; *pul.*, pulvinar; *rhinen.*, rhinencephalon; *s.n.comp.*, substantia nigra compacta; *s.n.ret.*, substantia nigra reticularis; *tr.opt.*, tractus opticus; *z.inc.caud.*, zona incerta caudalis; *z.inc.pr.*, zona incerta proper.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pul.
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a. pretect.
n. lat. ant.
n. post.
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n.lat.post.m.
n.supra-gen.
n.ant.vent.
n. com. post.
n.lim.
col. inf.
col. sup.
n. vent. ant.
n. caud.
n. vent. arc.
n. ret.
n. lat. teg.
cap. int.
n. vent. ext.
l.m.
n.inter-vent.
z. inc. pr.
ped. cer.
n. enloped.
H₂
n. subthal.
tr. opt.
pons
N.III
s. n. ret.
rhinen.
z. inc. caud.
s. n. comp.

17

PLATE 11

EXPLANATION OF FIGURE

18 Sagittal section passing through the medial margins of the geniculate bodies. Adult dog. Toluidin-blue preparation (1928.81: 1). × $5\frac{3}{8}$. *a.pretect.*, area pretectalis; *cap.int.*, capsula interna; *col.inf.*, colliculus inferior; *l.l.*, lemniscus lateralis; *n.caud.*, nucleus caudatus; *n.entoped.*, nucleus entopeduncularis; *n.g.l.d.m.*, nucleus geniculatus lateralis dorsalis, lamina magnocellularis; *n.g.l.d.parv.*, nucleus geniculatus lateralis dorsalis, lamina parvocellularis; *n.g.m.pr.*, nucleus geniculatus medialis, pars principalis; *n.lat.ant.*, nucleus lateralis anterior; *n.lat.inter.*, nucleus lateralis intermedius; *n.lat.post.v.*, nucleus lateralis pars posterior, portio ventralis; *n.lat.teg.*, nucleus lateralis tegmenti; *n.post.*, nucleus posterior; *n.ret.*, nucleus reticularis; *n.subthal.*, nucleus subthalamicus; *n.vent.ant.*, nucleus ventralis, pars anterior; *n.vent.arc.*, nucleus ventralis, pars arcuata; *n.vent.ext.*, nucleus ventralis, pars externa; *ped.cer.*, pedunculus cerebri; *pons*, pons; *pul.*, pulvinar; *rhinen.*, rhinencephalon; *s.n.comp.*, substantia nigra compacta; *s.n.ret.*, substantia nigra reticularis; *tr.opt.*, tractus opticus; *z.inc.caud.*, zona incerta caudalis; *z.inc.pr.*, zona incerta proper.


a. pretect.
pul.
n. lat. inter.
n. lat. ant.
n.g.l.d.parv.
n.g.l.d.m.
n. post.
n.lat.post.v.
n.g.m.pr.
n. caud.
n. vent. ant.
col. inf.
l.l.
n. lat. teg.
n. ret.
cap. int.
n. vent. ext.
n. vent. arc.
rhinen.
ped. cer.
tr. opt.
n. entoped.
pons
s. n. comp.
s. n. ret.
n. subthal.
z. inc. pr.
z. inc. caud.

18

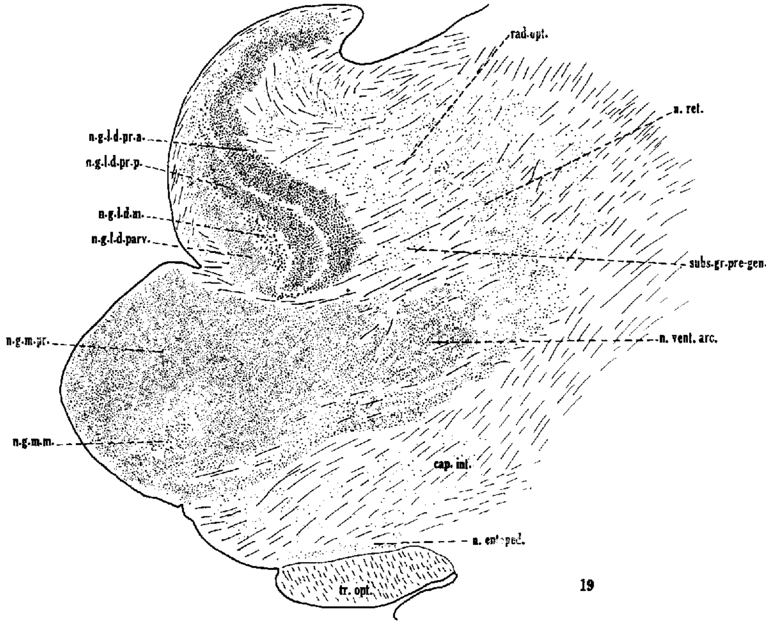
PLATE 12

EXPLANATION OF FIGURES

19 Sagittal section passing through the geniculate bodies. Adult dog. Toluidin-blue preparation (1928.50: 1). *cap.int.*, capsula interna; *n.entoped.*, nucleus entopeduncularis; *n.g.l.d.m.*, nucleus geniculatus lateralis dorsalis, lamina magnocellularis; *n.g.l.d.parv.*, nucleus geniculatus lateralis dorsalis, lamina parvocellularis; *n.g.l.d.pr.a.*, nucleus geniculatus dorsalis, lamina principalis anterior; *n.g.l.d.pr.p.*, nucleus geniculatus lateralis dorsalis, lamina principalis posterior; *n.g.m.m.*, nucleus geniculatus medialis, pars magnocellularis; *n.g.m.pr.*, nucleus geniculatus medialis, pars principalis; *n.ret.*, nucleus reticularis; *n.vent. arc.*, nucleus ventralis, pars arcuata; *rad.opt.*, radiatio optica; *subs.gr.pre-gen.*, substantia grisea pregeniculata; *tr.opt.*, tractus opticus.

20 Cells from the anterior group of nuclei. Toluidin-blue preparations. × 167. A. Cells from nucleus anterodorsalis, drawn from section 313: 1 (fig. 2). B. Cells of nucleus anteroventralis, large-celled portion, drawn from section 313: 1 (fig. 2). C. Cells of nucleus anteroventralis, small-celled portion, drawn from section 313: 1 (fig. 2). D. Cells of nucleus anteromedialis, drawn from section 313: 1 (fig. 2).

21 Cells from certain nuclei of the medial group. Toluidin-blue preparation. × 167. A. Cells of nucleus parataenialis, from section 313: 1 (fig. 2). B. Cells of nucleus medialis dorsalis, main portion, from section 288: 1 (fig. 5). C. Cells of nucleus medialis dorsalis, dorsomedial portion, from section 288: 1 (fig. 5). D. Cells of nucleus submedius, from section 288: 1 (fig. 5). E. Cells of nucleus centralis lateralis, from section 288: 1 (fig. 5). F. Cells of nucleus tractus habenulo-peduncularis lateralis, from section 265: 2 (fig. 7). G. Cells of nucleus parafascicularis, from section 248: 1 (fig. 9).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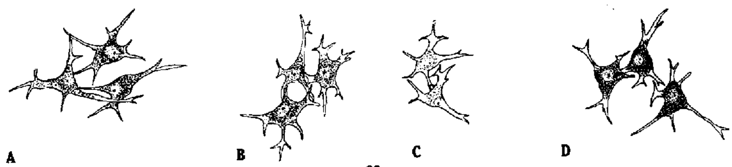
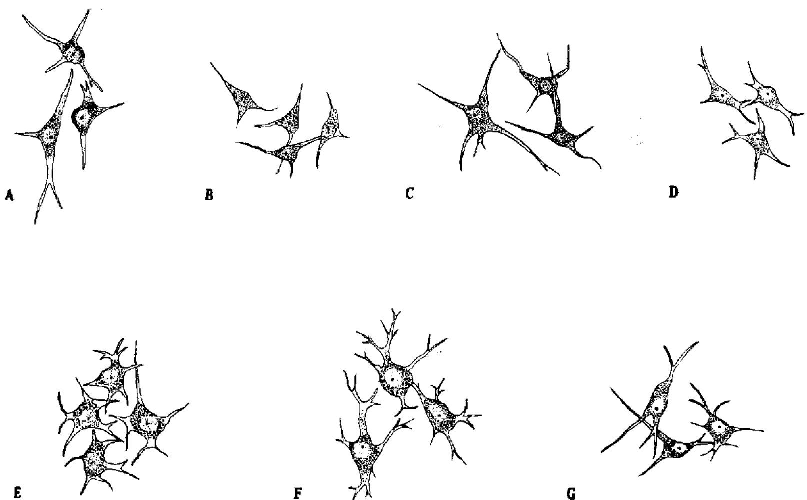
n.g.l.d.pr.p.
n.g.l.d.m.
n.g.l.d.parv.
subs.gr.pre-gen.
n.g.m.pr.
n. vent. arc.
n.g.m.m.
cap. int.
n. entoped.
tr. opt.

19


A
B
C
D

20


A
B
C
D
E
F
G

21

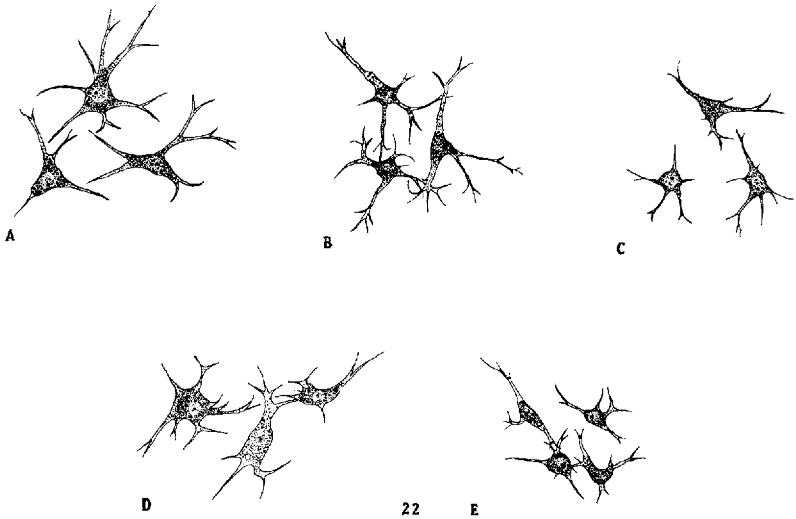
PLATE 13

EXPLANATION OF FIGURES

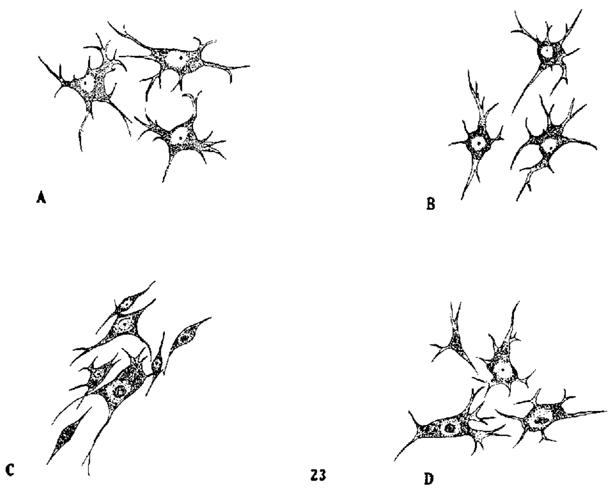
22 Cells from certain nuclei of the lateral group. Toluidin-blue preparation. × 167. A. Cells of nucleus lateralis, pars anterior, from section 288: 1 (fig. 5). B. Cells of nucleus lateralis, pars intermedius, from sagittal section 81: 1 (fig. 18). C. Cells of area pretectalis, from section 248: 1 (fig. 9). D. Cells of nucleus posterior, from section 229: 1 (fig. 12). E. Cells of nucleus reticularis, from section 301: 1 (fig. 4).

23 Cells from certain of the ventral nuclear group. Toluidin-blue preparation. × 167. A. Cells of the nucleus ventralis, pars anterior, from section 313: 1 (fig. 2). B. Cells of the nucleus ventralis, pars medialis, from section 307: 1 (fig. 3). C. Cells of the nucleus ventralis, pars externus, from section 258: 1 (fig. 8). D. Cells of the nucleus ventralis, pars arcuatus, from section 288: 1 (fig. 5).

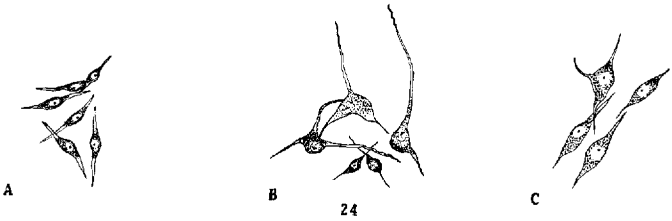
24 Cells from certain nuclei of the preoptic and hypothalamic areas. × 167. A. Cells of the medial preoptic area, from section 313: 1 (fig. 2). B. Cells of the nucleus filiformis principalis, from section 307: 1 (fig. 3). C. Cells of the nucleus tangentialis, from section 307: 1 (fig. 3).



22



23



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