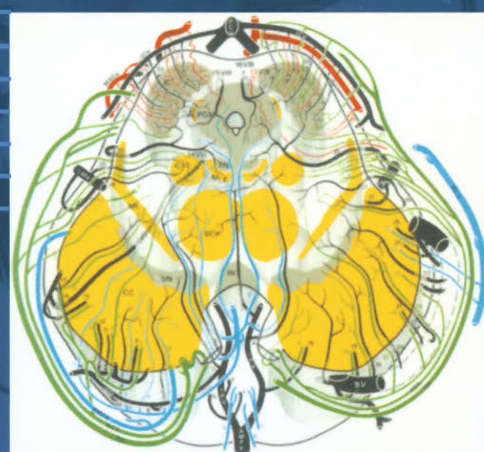
HENRI M. DUVERNOY

Human Brain Stem Vessels

Second Completely Revised and Expanded Edition



Including the Pineal Gland and Information on Brain Stem Infarction

Drawings by J. L. Vannson

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J. Bogousslavsky, E.A. Cabanis, M.T. Iba-Zizen, F. Cattin, and M. Gaudron

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With 187 Figures in 393 Parts

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This book is dedicated to my wife Odile
and to my sons Charles and David

Foreword

The first edition of *Human Brain Stem Vessels* by Dr. H.M. Duvernoy has been a standard reference for microneurosurgery since its publication in 1978. The present, second edition has been updated and produced in a handier format.

The evolution of technique in daily clinical routine has brought about more noninvasive investigations and computer-assisted procedures but also a decrease in optical solution of diagnostic images. We are particularly in danger of losing our imagination of vessel architecture and pathology of the brain as we knew it when angiography was the main imaging technique. On the other hand, minimally invasive techniques such as endoscopy offer more precision in visualizing a small region. It is mainly vessel texture which gives a fingerprint of a structure in the endoscopic view.

A neurologically unexpected course of disease in a patient and the results of surgery are directly related to the architecture of the vessels. Surgical strategies and the extent of trauma depend on the knowledge and the engram we have about the vessels in the affected area. In the age of "virtual reality" the scientific method has been preserved in the new edition of this book and the subject has been competently dealt with on the safe ground of reality.

K.D.M. Resch
Dresden, Germany

Preface

This book provides an overall view of the vascularization of the brain stem in man. The first part of the book concerns the superficial ramifications of the arteries and veins, their points of penetration into the nervous tissue or emergence from it and their corresponding territories of distribution into the brain stem. A special study of the vascularization of the pineal region is included in this part. The second part describes the fine internal vascular network and its correlation with the brain stem nervous structure. Finally, the vascular territories are compared with MRI views of brain stem infarction.

This book will be of interest for all who work in the field of neuroscience and particularly for neurologists, neurosurgeons and neuroradiologists concerned with the vascular diseases in the brain.

Henri Duvernoy

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I would first like to express my gratitude to the late Professor Roger WARWICK who collaborated on the first edition of this book.

I will acknowledge the help of the members of the department of Anatomy: Professor J. GUYOT, Professor G. MONNIER, Dr. B. PARRATTE, Dr. L. TATU, Dr. F. VUILLIER, Dr. V. GRELET and Mr. P. BOUVOT.

This book would not have been possible without the excellent illustrations by J.L. VANNSON, the technical assistance of Mrs. J. EUVRARD and Dr. A. GOUGET and the clear photographs produced by Miss A. BARTHELET.

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Contents

Introduction

The aim of this book is to provide an overall view of the vascularization of the brain stem in man, comprising the arteries, the veins and the capillary network.

Existing literature on the subject is lacking in detailed descriptions of the small arterial rami, of their superficial paths and of their deep distribution. Similarly, the superficial and deep paths of the veins of the brain stem have received too little attention. The capillary network of the brain stem, especially in man, is relatively unknown.

The conclusions to this book will show that there are still many gaps in our knowledge of this subject.

However, it is hoped that this book will be of use not only to human anatomists but also to neurologists, neurosurgeons and neuroradiologists. Since it has been written mainly for such specialists, we have, as far as possible, chosen to use terminology consistent with the anatomical position of the human brain stem.

The book is divided into two parts, the first dealing with the arteries and veins, the second with the vascular network. Each part, therefore, has its own concluding remarks.

The *first part* concerns the superficial ramifications of the arteries and veins, their points of penetration into the nervous tissue or emergence from it and their corresponding territories of distribution. Only an overall view of the larger arteries and veins of mesencephalon, pons and medulla will be found in this book.

For more information (especially about variations), readers are referred to the classic literature on the subject, and especially to DURET (1874), STOPFORD (1916a, b), FOIX and HILLEMAND (1925a, c), LAZORTHES (1961), KAPLAN and FORD (1966), KRAYENBUHL and YASARGIL (1968), STEPHENS and STILWELL (1969), SALAMON (1973), NEWTON and POTTS (1974), LAZORTHES et al. (1976), SALAMON and HUANG (1976) for the arteries and to HUANG and WOLF (1968, 1974), TOURNADE et al. (1972) and DUVERNOY (1975) for the veins.

In addition, this book contains a precise study of the brain stem vascularization. The blood vessels supplying the brain stem have been classified from different points of view. The most widely used classification (Fig. 15a) is that used by FOIX and HILLEMAND (1925a and b) based on the origin of arteries from the main arterial trunks. So, the arteries supplying the brain stem were divided into paramedian (PM), short circumferential (SC), and long circumferential (LC). This classification has two disadvantages: the first is that the main arterial trunks supplying the brain stem (vertebral, basilar, cerebellar and posterior cerebral arteries) have numerous variations in their path and the second is that this classification does not take into account the veins of the brain stem. So we prefer the classification (Fig. 15b) proposed by GILLILAN (1964) and LAZORTHES et al. (1976) who divided the blood vessels supplying the brain stem into anterior, lateral and posterior groups according to the more constant point of penetration of arteries (or emergence of veins) into the corresponding anterior, lateral and posterior brain stem surfaces described in Figs. 2, 3 and 4. The vessels of the anterior group can be subdivided into anteromedial (paramedian according to FOIX and HILLEMAND) and anterolateral groups.

At the beginning of *Part I* (Figs. 16–19), the reader will find a specific study of the arteries and veins including the origin of the different groups of vessels supplying the brain stem. This first step is important for the understanding of the subsequent description of arteries and veins studied together. Thus, this preliminary study is followed by specialized studies of the arteries and veins of the medulla, pons and mesencephalon. This part is illustrated by numerous observations of brain stem superficial arteries and veins made after intravascular india ink injection, and is preceded by the precise study of superficial and internal vessels of a single brain stem which appears to be a particularly representative specimen among all the brains examined. Ten sections of the brain stem are presented, showing the deep courses of the vessels, the superficial paths of which can be seen in the drawings of the anterior, posterior and lateral surfaces. The drawings of the lateral surfaces of the midbrain are to be found in the text and those of the anterior and posterior surfaces illustrating the whole brain stem are to be found at the end of the book. Readers will find general views of the territories vascularized by the arteries and veins of the different groups in the inset drawings in each of the ten sections.

Part II of this book concerns the capillary network of the brainstem and is illustrated by photographs of transverse, coronal and sagittal sections showing the vascular architecture of the medulla, the pons and the midbrain.

In this *new edition* (the first edition was published in 1978), the main organization of the book is unchanged. However, many dissections have been added especially showing the brain stem veins which were poorly represented in the literature and the dense and complex vascularization of the pineal and collicular regions. Concerning the vascular network of the brain stem, new preparations have been added and the plane of each transverse section has been specified.

Finally, *in Part III* of this book, the ten sections cited above with their structures and vascular territories have been compared to MRI views. Some aspects of brain stem infarction corresponding to the vascular territories have been added to this new edition.

Material and Methods

This research is based on the study of 150 brains; all were taken from the autopsy room as soon as possible all within 12 hours after death.

Two methods of vascular injections were applied:

1. Intravascular india ink injection. This method was most often utilized in this work. In these cases, a mixture of india ink and 5% gelatin was injected into the vascular system of the brain. A preliminary injection of india ink and water (without gelatin) was sometimes used to obtain a better filling of the smaller capillaries. It must be stated that the quality of the injections varied considerably and that successful results depended to a large extent on the age of the subject and the interval between death and injection.
2. Intravascular injection with low viscosity resin (Mercox). This method was used only for some views concerned with the vascularization of the pineal gland. For the detailed description of this method see Duvernoy et al. (1981, 1983).

Different observation techniques were used for the superficial vessels, the internal vessels and the capillary network of the brain stem.

1. Technique for Superficial Vessels

Superficial arteries and veins were dissected under a stereoscopic microscope, with the brain stem immersed in distilled water, and the trabeculae of the arachnoid mater were removed. The point of penetration into the nervous tissue or emergence from it was identified at this stage. The preparation was photographed from various angles to provide a reference for the next stage.

2. Technique for Internal Vessels and Their Territories

The internal vessels and their territories were studied in serial transverse sections (2–3 mm thick), the exact limits of each section being plotted on the photograph of the whole brain stem. These serial sections were observed under a stereoscopic microscope after full clearing (Spalteholz's technique). The courses of vessels were followed through the nervous tissue from their points of penetration or emergence noted on the photographs. In this way, the internal distribution of the veins and arteries can be followed in detail and their rami and anastomoses can be identified. Figures 24–33 show arterial and venous territories identified by the complete observation of one brain stem. The mapping proposed here may vary to some extent, although a less detailed examination of ten other brain stems appears to confirm the initial conclusions presented in this work.

A disadvantage of this method is the length of time required for complete, detailed observation of even one brain stem. For this reason, only ten brain stems were studied completely for the deep courses and territories.

The main advantage of this technique is that it enables a clear distinction to be made between arteries and veins, because both are followed from points previously noted on the surface and identified in the photographs. Distinction between internal artery and vein has always been a difficult matter in spite of the supposed difference in branching. After Campbell (1938), Scharrer (1940) observed that the branches of an artery usually arise at an acute angle and follow a smooth curved path, whereas veins are more often joined by branches at right angles. Scharrer's observations were later confirmed by Hasegawa et al. (1967) and Duvernoy et al. (1981, 1983).

Great caution must be used in distinguishing between arteries and veins in this way, and numerous errors of interpretation are possible if the vessels are not followed from the surface.

Another advantage of this method is that it enables a clear definition of anastomoses to be made. In thin sections, it is often difficult to distinguish between superimposed vessels and anastomoses.

Finally, the method allows each vessel to be followed to its smallest rami, thus permitting a detailed description of its territory of distribution.

The technique of total injection is, in the experience of this study, preferable to that of partial injections, a method which has been rightly criticized by METTLER et al. (1954) as being too far removed from normal conditions and as being subject to variations due to the presence of superficial anastomoses. Finally, this technique of total injection allows a good observation of the venous network which is incompletely seen in the retrograde venous injection usually found in the literature.

3. Technique for the Capillary Network of the Brain Stem

The vascular network of various nuclei and tracts was first studied in thick sections. It was then observed in greater detail in 300 µm serial sections after embedding in paraffin from 43 brain stems cut in transverse, coronal, and sagittal sections. Bodian's silver impregnation technique was used in thin sections (15 µm) to assist in identification of nuclei and tracts. With this method, the difference in vascular density between white and grey matter, and even between the various nuclei, makes the identification of numerous cerebral structures possible.

A Survey of the Brain Stem Morphology

This overview of the brain stem surface and division is essential to a good understanding of its vascularization. To simplify the description, the anatomy of the brain stem will be presented in several drawings and dissections with comments, based on a previous work (DUVERNOY 1995) (Figs. 1–14).

Figures 2, 3 and 4 show anterior, posterior and lateral views of the brain stem which has been separated from the cerebellum by sections of the cerebellar peduncles.

Each of the three segments of the brain stem (medulla, pons, and mesencephalon) shows different surfaces – anterior, posterior, and lateral – which will be described in turn.

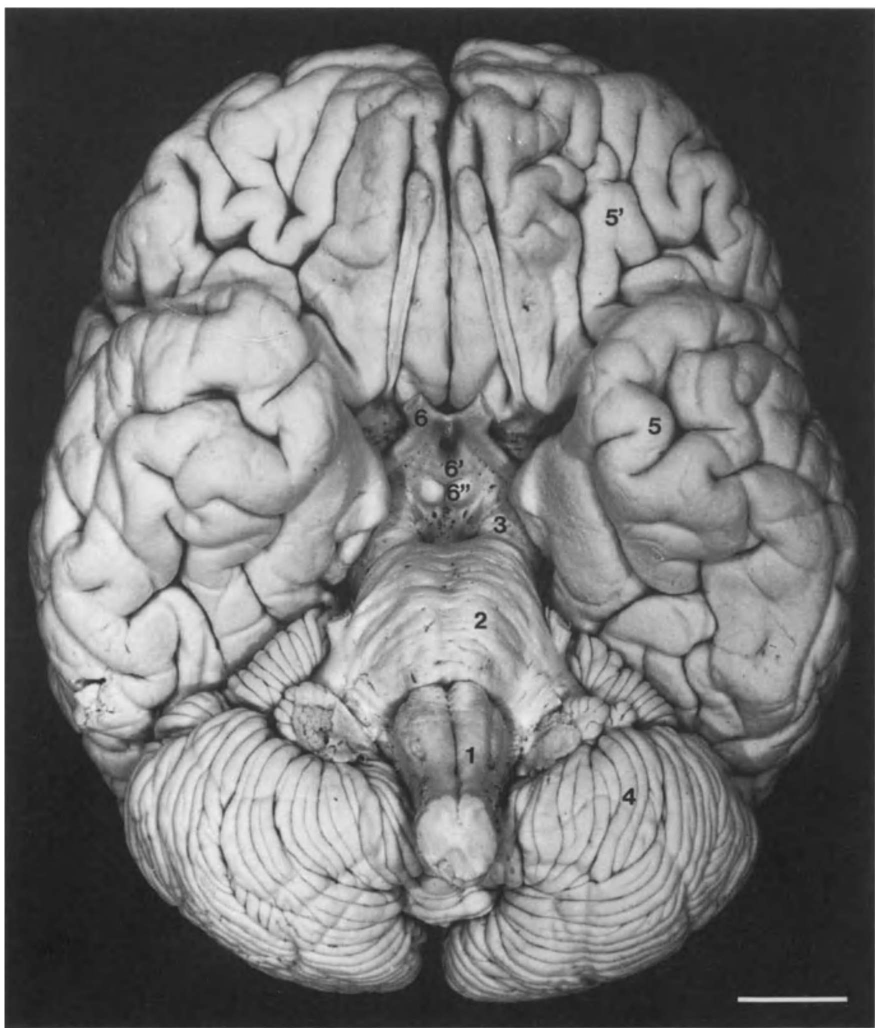


Fig. 1. Ventral Aspect of the Encephalon. **Bar, 16.5 mm** The brain stem is made up of three parts in ascending order: the medulla (**1**), pons (**2**) and mesencephalon (midbrain) (**3**). The brain stem is linked posteriorly to the cerebellum (**4**) and superiorly to the brain (*stricto sensu*) composed of the cerebral hemispheres and diencephalon; **5**, temporal lobe; **5'** frontal (orbital lobe). Only a restricted surface of the diencephalon is visible in this ventral view: **6** optic chiasma; **6'** tuber cinereum; **6"** mamillary body

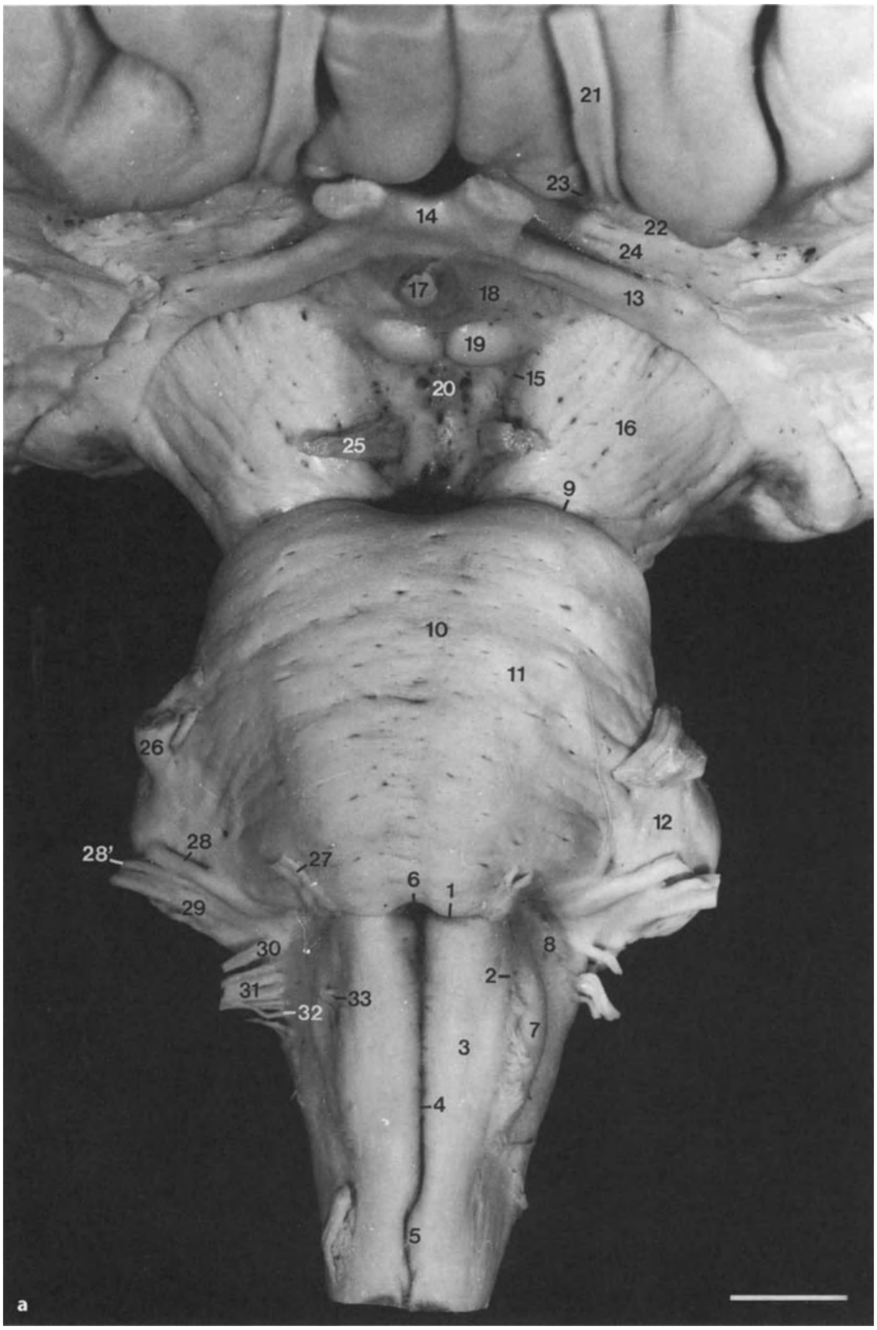


Fig. 2. Anterior View of the Brain Stem. Bar, 7.4 mm

Medulla: The boundaries between spinal cord and medulla are noted on Fig. 13. The pontomedullary sulcus (**1**) separates the medulla from the pons

Anterior surface: **2**, anterolateral (preolivary) medullary sulcus; **3**, pyramid of the medulla (including corticospinal tract); **4**, anteromedian medullary sulcus; **5**, decussation of the pyramids (spinomedullary junction); **6**, foramen caecum

Lateral surface: **7**, inferior olive; **8**, lateral medullary fossa: this fossa is limited medially by the inferior olive (*7*), laterally by the roots of glossopharyngeal (*30*)and vagus (*31*) nerves and superiorly by the pontomedullary sulcus (*1*) with the roots of facial (*28*)and vestibulocochlear (*29*) nerves

Pons: On a transverse section (Fig. 2c), the pons is divided along a frontal plane passing through the medial lemniscus (*A*) into the ventral (basilar) part (*B*) and the tegmentum (*C*). The pons is separated from the medulla by the pontomedullary sulcus (*1*) and from the mesencephalon by the pontomesencephalic sulcus (**9**)

Anterior surface: **10**, basilar sulcus; **11**, ventral (basilar) part of the pons. The lateral surface of the pons (**12**) ends with the middle cerebellar peduncle (brachium pontis)

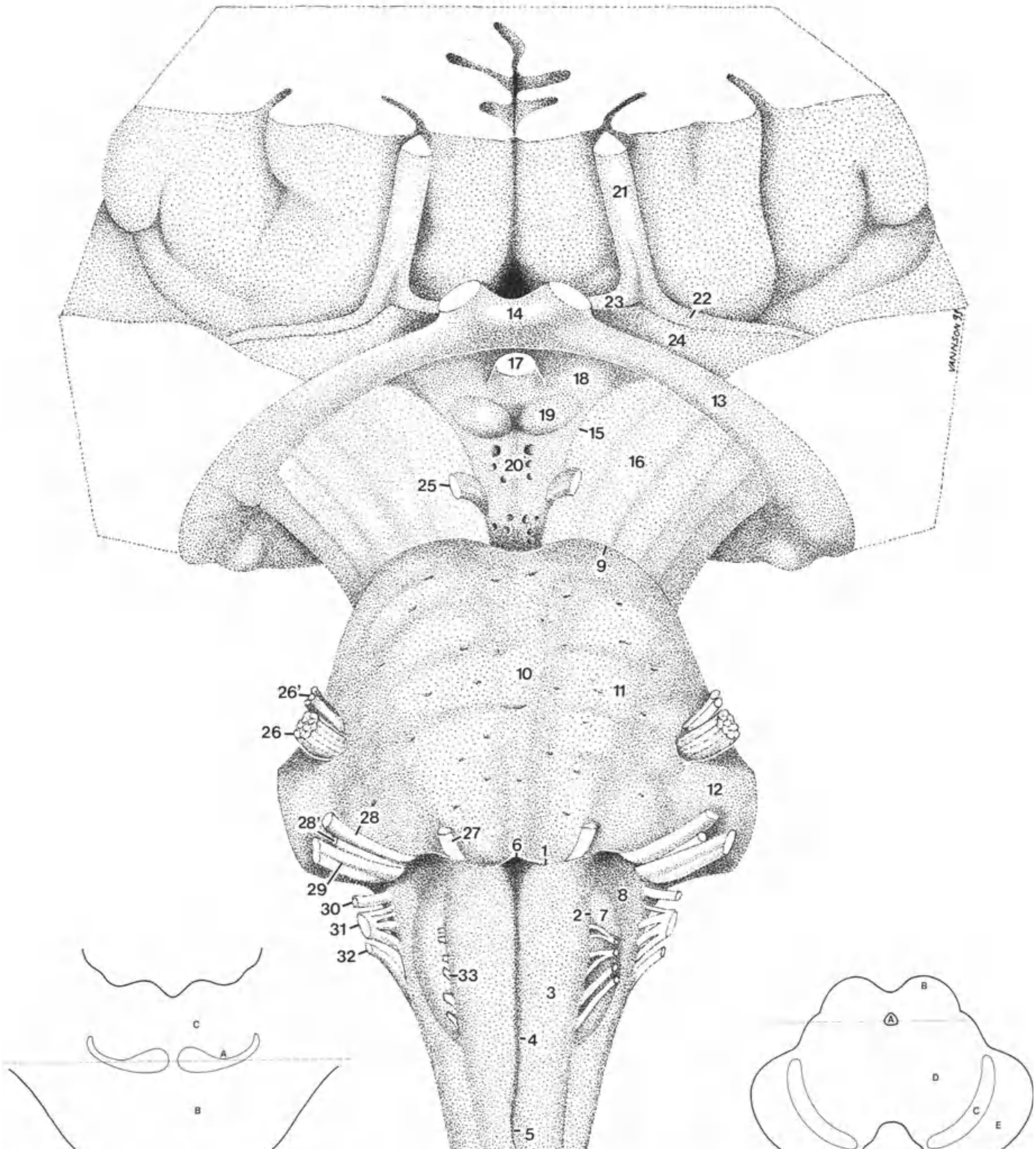


Fig. 2c Fig. 2b Fig. 2d

Mesencephalon: On a transverse section (Fig. 2d), the mesencephalon is divided along a frontal plane passing through the cerebral aqueduct (*A*), dorsally into the tectum (*B*) and ventrally into the cerebral peduncle, which is itself divided by the substantia nigra (*C*) in tegmentum (*D*) and crus cerebri (pes pedunculi) (*E*). The mesencephalon is separated from the pons by the pontomesencephalic sulcus (*9*) and from the brain by the optic tract (**13**), optic chiasma (**14**) and the medial mesencephalic sulcus (**15**). The anterior surface of the mesencephalon consists of the crus cerebri (pes pedunculi or basis pedunculi, **16**). The interpeduncular region, which belongs to the diencephalon, includes the hypophysial stalk (**17**), tuber cinereum (**18**), mamillary bodies (**19**), and interpeduncular fossa (posterior perforated substance) (**20**). Also shown are the olfactory tract (**21**), dividing into lateral (**22**) and medial (**23**) olfactory striae bordering the anterior perforated substance (**24**). Roots of the cranial nerves: **25**, oculomotor nerve; **26**, trigeminal nerve (sensory root); **26'**, trigeminal nerve (motor root); **27**, abducent nerve; **28**, facial nerve; **28'**, nervus intermedius; **29**, vestibulocochlear nerve; **30**, glossopharyngeal nerve; **31**, vagus nerve; **32**, accessory nerve (medullary root); **33**, hypoglossal nerve

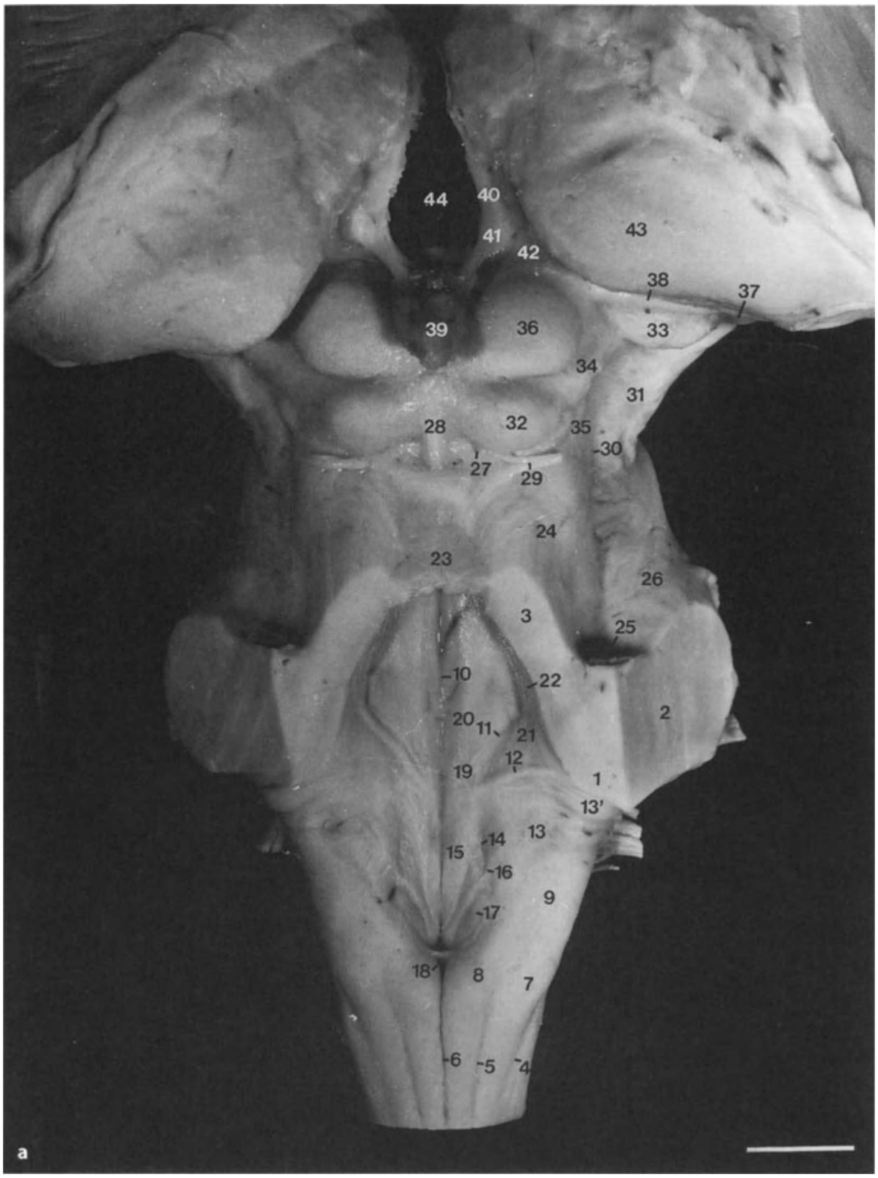


Fig. 3. Posterior View of the Brain Stem. The cerebellum was removed by sectioning of the three cerebellar peduncles: inferior (restiform body) (**1**), middle (brachium pontis) (**2**), and superior (brachium conjunctivum) (**3**). **Bar, 8.3 mm**

Medulla – *posterior surface:* the medulla is divided into superior and inferior levels. The former belongs to the floor of the fourth ventricle and the latter extends to the posterior surface of the spinal cord

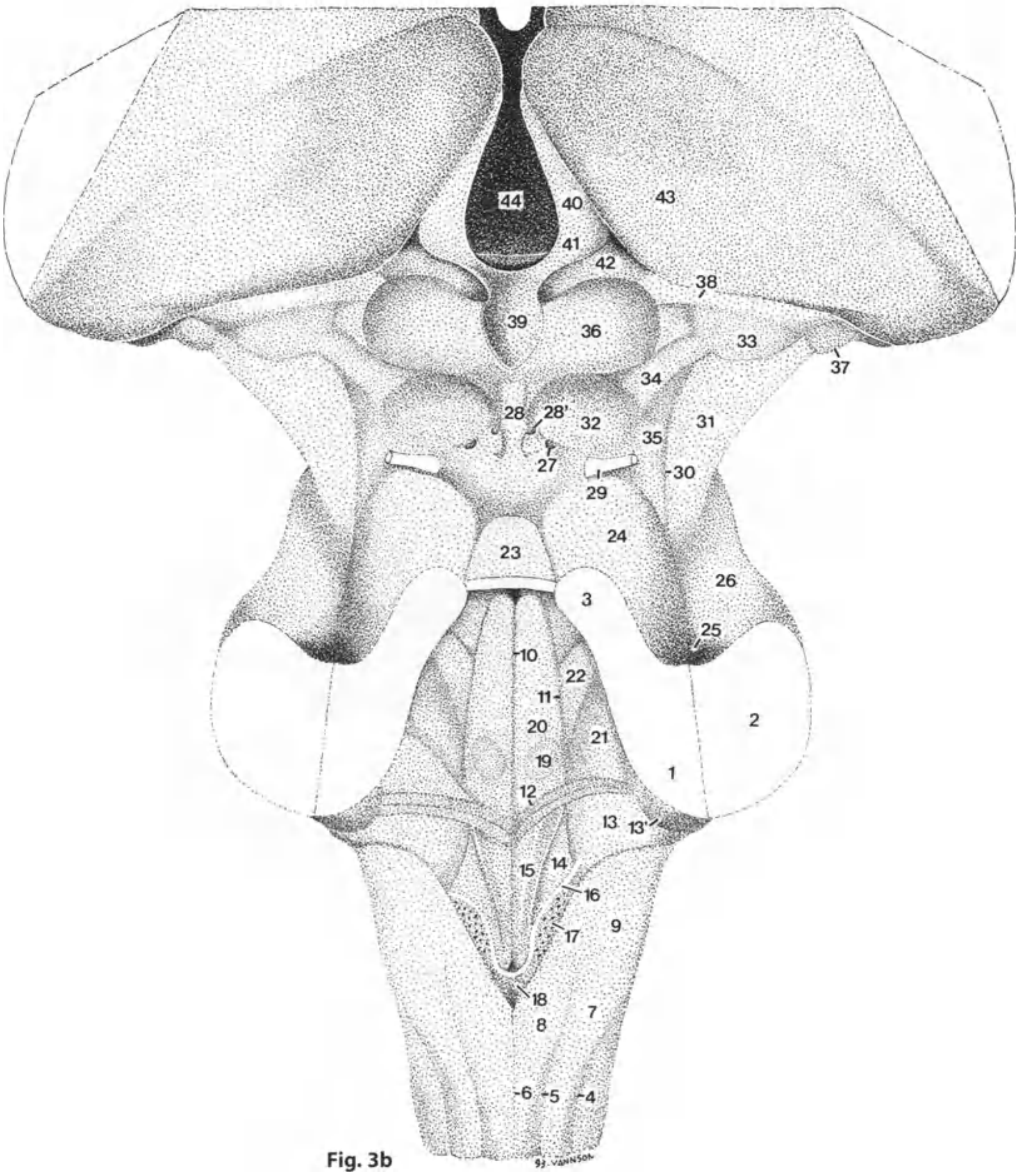
Inferior level: **4**, posterolateral medullary sulcus; **5**, posterior intermediate medullary sulcus; **6**, posteromedian medullary sulcus. The cuneate (**7**) and gracile (clava) (**8**) tubercles are produced by the subjacent cuneate and gracile nuclei (see Fig. 99)

Superior level: the superior level is composed of the medullary part of the fourth ventricle floor (which will be studied later together with the pontine part) laterally bordered by the right and left inferior cerebellar peduncles (restiform bodies) (**9**)

Pons – *posterior aspect:* the posterior aspect is composed of a restricted superior part, the superior cerebellar peduncles (brachia conjunctiva) (*24*) and a large inferior part which consists of the pontine (superior) triangle of the fourth ventricle floor

Floor of the fourth ventricle: the floor or rhomboid fossa (see Fig. 9) shows one median sulcus (**10**) and the two, right and left limitans sulci (**11**). The striae medullares (**12**) divide the floor into the two, inferior medullary and superior pontine triangles

The *medullary triangle* consists of three segments that run from the lateral region to the median line: **13**, the medullary vestibular area due to the protrusion of the medial vestibular nucleus; **13'**, acoustic tubercle; **14**, the vagal trigone (fovea



inferior) corresponding to the dorsal motor vagal nucleus; **15**, the hypoglossal trigone produced by the subjacent hypoglossal and intercalatus nuclei. A thickening of the ependyma, the funiculus separans (**16**), borders the area postrema (**17**). **18**, Obex and funicular commissure

The *pontine triangle* consists of: **19**, the facial colliculus (protrusion due to the abducent nucleus and the facial nerve fibers); **20**, the medial eminence; **21**, the pontine vestibular area; **22**, and the fovea superior. **23**, Superior medullary velum linking the right and left superior cerebellar peduncles (brachium conjunctivum) (**24**); **25**, parabrachial recess situated between the brachium conjunctivum (**24**) and brachium pontis (**26**)

Mesencephalon – posterior and lateral surfaces: **27**, infracollicular recess (emergence of deep veins (see p. 44); **28**, frenulum veli (**28'**, recess of the frenulum veli); **29**, root of trochlear nerve; **30**, lateral mesencephalic sulcus bordering the crus cerebri (**31**); **32**, inferior colliculus linked to the medial geniculate body (**33**) by the inferior collicular brachium (**34**); **35**, lateral aspect of mesencephalon; **36**, superior colliculus linked to the lateral geniculate body (**37**) by the superior collicular brachium (**38**); **39**, pineal gland; **40**, stria medullaris; **41**, habenula; **42**, pretectal area; **43**, thalamus (pulvinar); **44**, third ventricle

Fig. 4. Right Lateral View of the Brain Stem. Bar, 6.6 mm

Medulla – *lateral surface,* inferior level: **1**, lateral medullary funiculus; superior level: **2**, inferior cerebellar peduncle (restiform body); **3**, inferior olive

Pons – *lateral surface:* this surface mostly consists of the middle cerebellar peduncle (brachium pontis) (**4**); **5**, superior cerebellar peduncle (brachium conjunctivum); **6**, parabrachial recess; **7**, anterior surface of the pons

Mesencephalon – *lateral surface:* this lateral surface is also known as acoustic or lemniscal trigone due to the subjacent lateral lemniscus (auditory fibers). Triangular-shaped, the lateral surface of the mesencephalon (**8**) is bordered laterally by the lateral mesencephalic sulcus (**9**), cranially by the inferior colliculus (**10**), the inferior collicular brachium (**11**) and the medial geniculate body (**12**), and caudally by the superior cerebellar peduncle (5) or brachium conjunctivum.
13, crus cerebri; **14**, pontomesencephalic sulcus; **15**, superior colliculus; **16**, lateral geniculate body; **17**, optic tract;

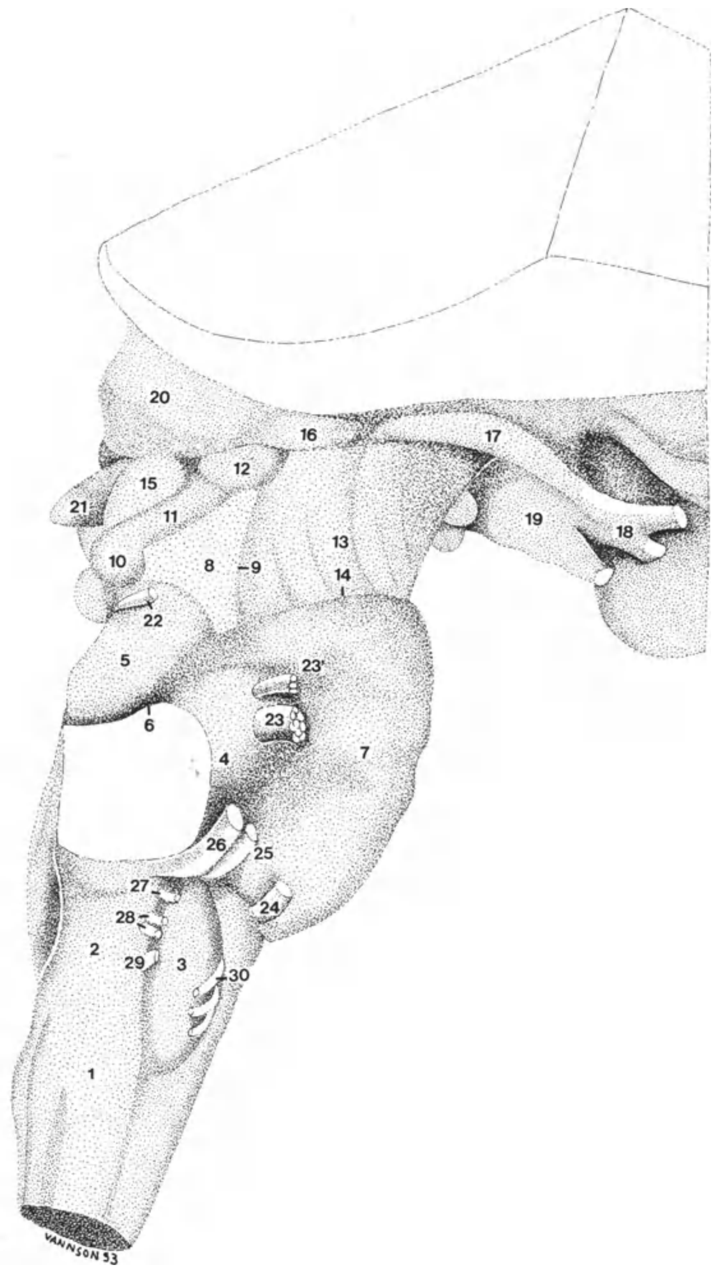


Fig. 4b

18, optic chiasma; **19**, median eminence of the left infact; **20**, pulvinar; **21**, pineal gland
Roots of cranial nerves; **22**, trochlear nerve; **23**, trigeminal nerve, sensory root; **23'**, trigeminal nerve, motor root; **24**, abducent nerve; **25**, facial nerve; **26**, vestibulocochlear nerve; **27**, glossopharyngeal nerve; **28**, vagus nerve; **29**, accessory nerve (medullary root); **30**, hypoglossal nerve

Figures 5, 6 and 7 show the relationships between brain stem and cerebellum and the emergence of cranial nerves

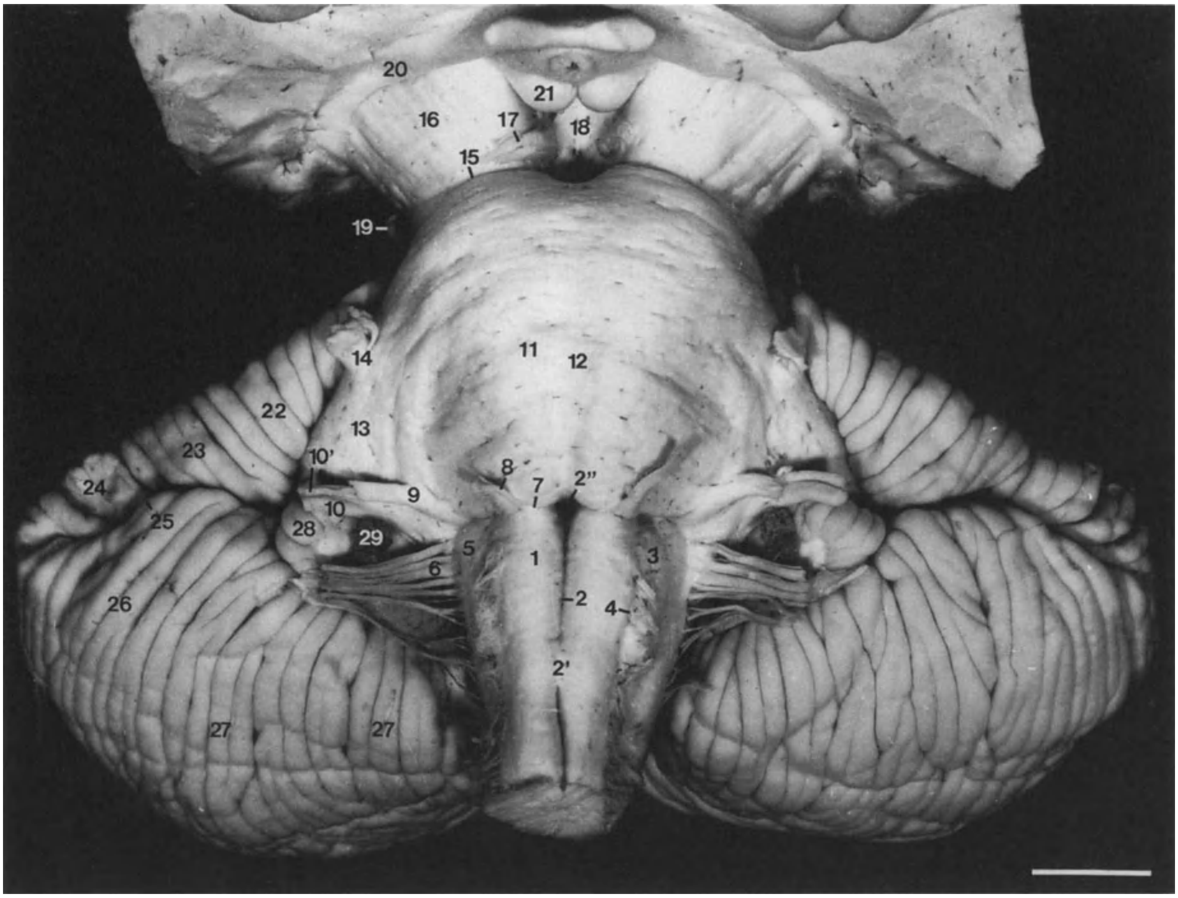


Fig. 5. Anterior View of the Brain Stem and Cerebellum
Bar, 9.5 mm

Medulla: 1, pyramid of the medulla; 2, anteromedian medullary sulcus; 2', decussation of the pyramids; 2", foramen caecum; 3, inferior olive; 4, anterolateral (preolivary) medullary sulcus and hypoglossal nerve root; 5, lateral medullary fossa; 6, roots of glossopharyngeal, vagus, and accessory nerves from upper to lower levels

Pons: 7, pontomedullary sulcus; 8, abducent nerve; 9, facial nerve; 10, vestibulocochlear nerve; 10', nervus intermedius; 11, anterior surface of the pons (ventral or basilar part); 12, basilar sulcus; 13, lateral surface of the pons extending to the middle cerebellar peduncle (brachium pontis); 14, trigeminal nerve

Mesencephalon: 15, pontomesencephalic sulcus; 16, crus cerebri; 17, oculomotor nerve; 18, interpeduncular (intercrural) fossa; 19, trochlear nerve; 20, optic tract; 21, mamillary body

Cerebellum: 22, quadrangular lobule; 23, simple lobule; 24, superior semilunar lobule; 25, horizontal fissure; 26, inferior semilunar lobule; 27, biventer lobule; 28, flocculus; 29, lateral aperture and extraventricular choroid plexuses of the fourth ventricle

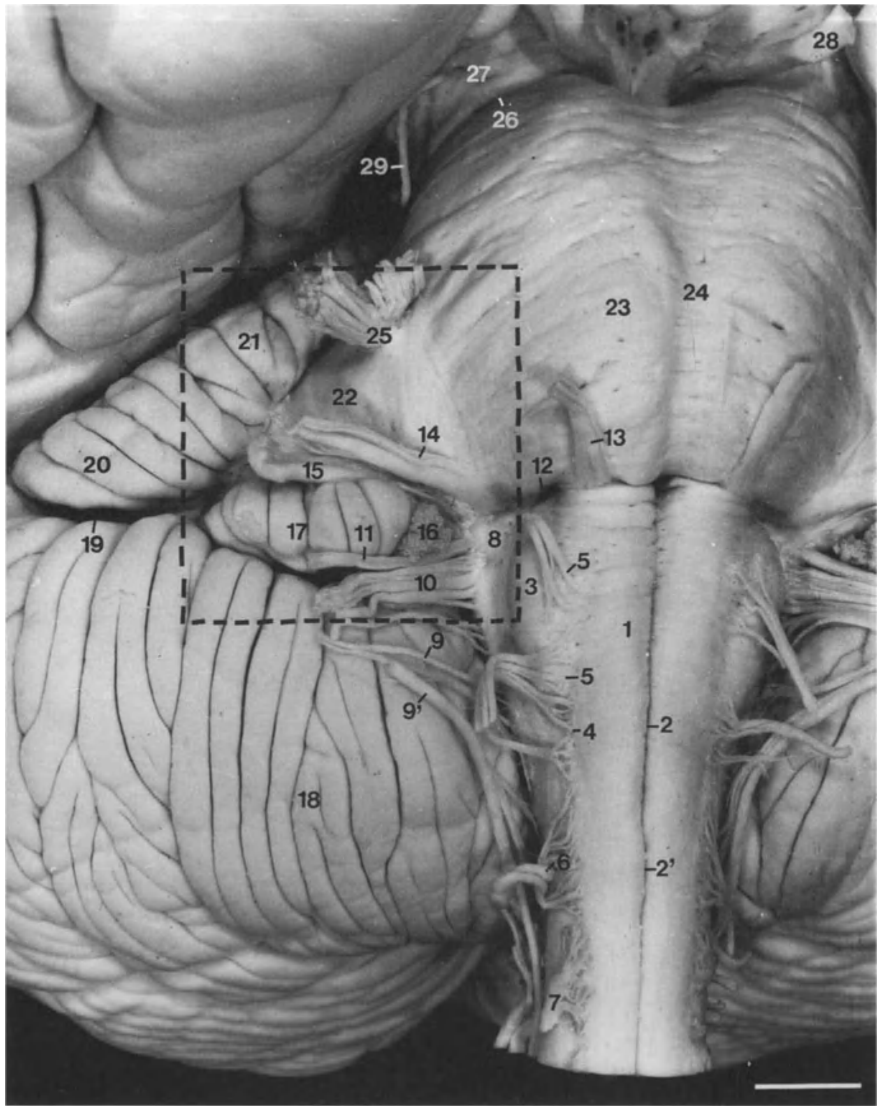


Fig. 6. Anterior View of the Brain Stem and Cerebellum: Emergence of the Roots of the Cranial Nerves. Bar, 6.6 mm

1, Pyramid of medulla; **2**, anteromedian medullary sulcus; **2'**, decussation of the pyramids; **3**, inferior olive; **4**, anterolateral (preolivary) medullary sulcus; **5**, roots of the hypoglossal nerve stemming from the anterolateral medullary sulcus; **6**, root of the first cervical nerve; **7**, ventral root of the second cervical nerve; **8**, lateral medullary fossa
From the lateral surface of the medulla emerge successively in ascending order: **9**, medullary root of the accessory nerve (**9'**, spinal root of the accessory nerve); **10**, vagus nerve; **11**, glossopharyngeal nerve; **12**, pontomedullary sulcus and emergence of: **13**, abducent nerve; **14**, facial nerve; **15**, vestibulocochlear nerve. **16**, Lateral aperture and choroid plexuses of the fourth ventricle; **17**, flocculus; **18**, biventer lobule; **19**, horizontal fissure; **20**, simple lobule; **21**, quadrangular lobule; **22**, lateral surface of the pons (middle cerebellar peduncle, brachium pontis); **23**, anterior surface of the pons; **24**, basilar sulcus; **25**, trigeminal nerve (sensory root); **26**, pontomesencephalic sulcus; **27**, crus cerebri; **28**, oculomotor nerve; **29**, trochlear nerve
The dotted line indicates the area of the cerebellopontine angle (some researchers restrict this area to the flocculus and the emergence of facial and vestibulocochlear nerves)

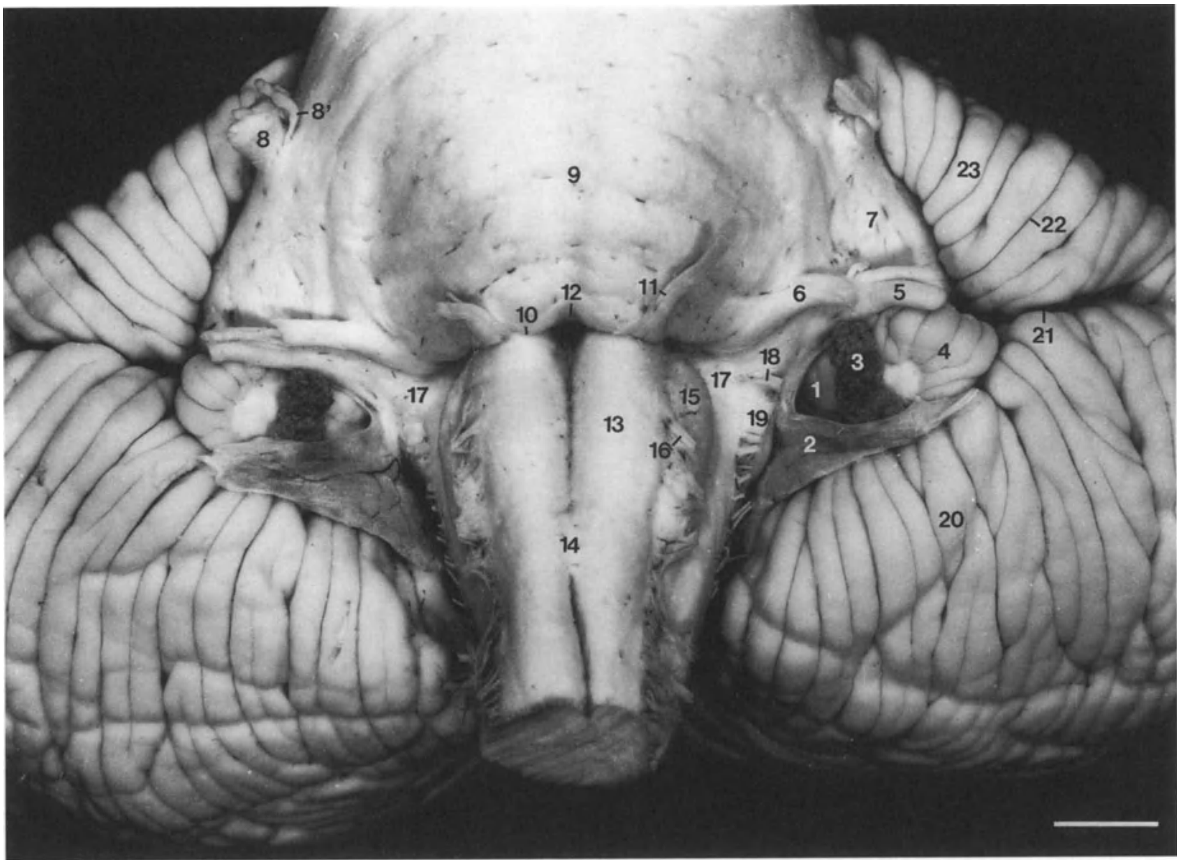


Fig. 7. Anterior View of the Brain Stem and Cerebellum
Bar, 5.7 mm

The roots of the cranial nerves have been cut off to study with more detail the lateral aperture (1) of the fourth ventricle (see following figures) and the boundaries of the lateral medullary fossa (17)

1, Lateral aperture of the fourth ventricle (foramen of Luschka); **2**, anterior ligula which is an extension of the posterior ligula seen on the posterior surface of the medulla (Fig. 9); **3**, extraventricular choroid plexuses. The lateral aperture of the fourth ventricle is part of the cerebellopontine angle (see Fig. 6). **4**, Flocculus; **5**, vestibulocochlear nerve; **6**, facial nerve; **7**, middle cerebellar peduncle (brachium pontis); **8**, trigeminal nerve (sensory root); **8'**, trigeminal nerve (motor root); **9**, pons (ventral part); **10**, pontomedullary sulcus; **11**, abducent nerve; **12**, foramen caecum; **13**, pyramid of the medulla; **14**, decussation of the pyramids; **15**, inferior olive; **16**, hypoglossal nerve; **17**, lateral medullary fossa; **18**, glossopharyngeal nerve; **19**, vagus nerve; **20**, biventer lobule; **21**, horizontal fissure; **22**, anterior superior (primary) fissure; **23**, quadrangular lobule

Figures 8–12 show an overview of the fourth ventricle. The fourth ventricle (rhombencephalic ventricle) is located in the pons, medulla and cerebellum (which together compose the rhombencephalon). It communicates in its upper part with the cerebral aqueduct and in its lower part with the central canal situated inside the medulla and spinal cord. The fourth ventricle is the only ventricular cavity to have apertures allowing the ventricular fluid secreted by the choroid plexuses to flow into the subarachnoid spaces.

Fig. 8. General Features of the Fourth Ventricle. On this median section, the fourth ventricle is a triangular-shaped cavity with a floor (**1**) (rhomboid fossa) and a roof. The floor composed by the medulla (**3**) inferiorly and the pons superiorly (**4**), will be studied in the following figures (for more details about the fourth ventricle see DUVERNOY 1995). The roof has three parts: a fastigium (fastigial sulcus) (**2**) between two, superior (**2'**) and inferior (**2"**) parts. **3**, Medulla; **4**, pons; **5**, mesencephalon; **6**, cerebellum (vermis); **7**, nodulus; **8**, central canal; **9**, cerebral aqueduct; **10**, posterior commissure; **11**, pineal gland; **12**, anterior commissure; **13**, third ventricle

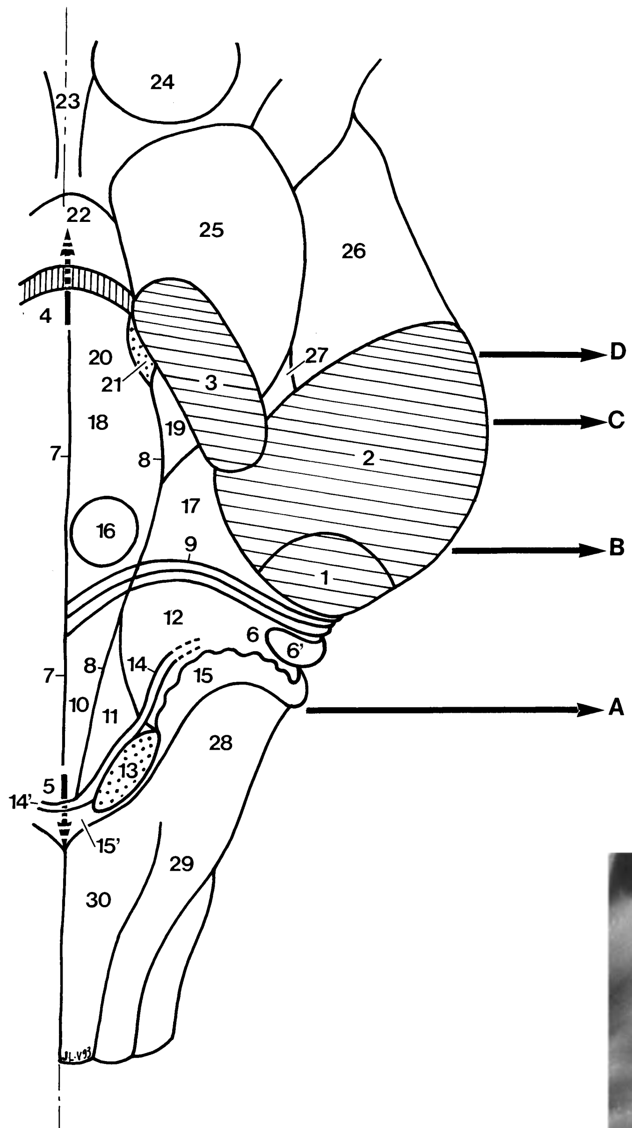


Fig. 9a. Floor of the Fourth Ventricle (rhomboid fossa, right side)

Posterior view after removal of the cerebellum, by section of the inferior (1), middle (2), and superior (3) cerebellar peduncles. The floor of the fourth ventricle is rhomboid-shaped. At its superior angle (4) it is continuous with the cerebral aqueduct and at its inferior angle (5), with the central canal. Each lateral angle or lateral recess of the fourth ventricle (6), shows a small protrusion, the acoustic tubercle produced by the subjacent dorsal cochlear nucleus (6′). The floor is split vertically by a median sulcus (7) and on each side by a limitans sulcus (8). The striae medullares (9) (aberrant pontocerebellar fibers) cross the floor from its lateral angle to the median sulcus and divide the ventricular floor into two, inferior medullary and superior pontine triangles

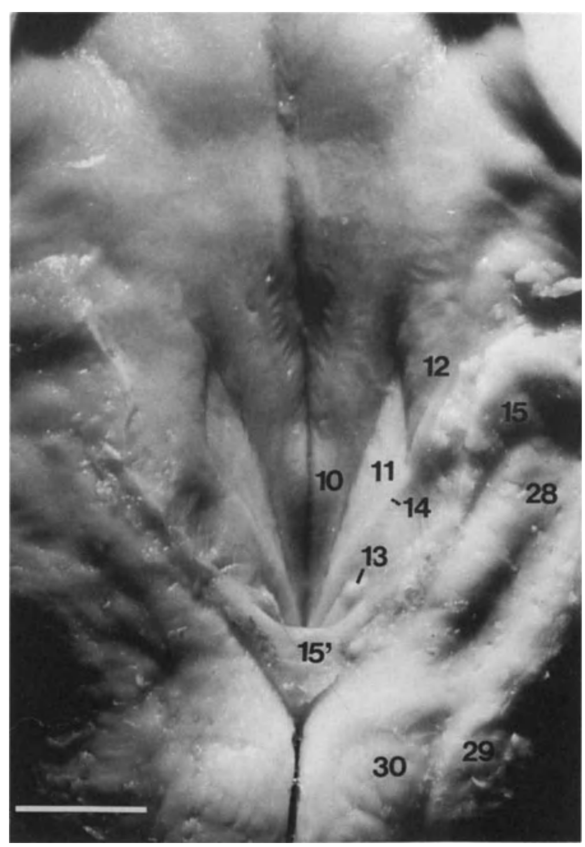


Fig. 9b. Bar, 3.5 mm

Superior (pontine) triangle: it can be divided into inferior, middle, and superior levels

Superior level (**D**): **20**, medial eminence (**20′** medial longitudinal fasciculus); **21**, locus coeruleus (**21′** nucleus coeruleus); **22**, superior medullary velum overlapping the superior angle of the ventricular floor; **23**, frenulum veli; **24**, inferior colliculus; **25**, superior cerebellar peduncle (brachium conjunctivum); **26**, middle cerebellar peduncle (brachium pontis); **27**, parabrachial recess; **28**, inferior cerebellar peduncle (restiform body); **29**, cuneate tubercle; **30**, gracile tubercle (clava)

Middle level (**C**): **18**, medial eminence (**18′** medial longitudinal fasciculus); **19**, superior fovea (fovea trigemini) corresponding to the motor trigeminal nucleus (**19′**); (**19″** principal sensory trigeminal nucleus)

Inferior level (**B**): **16**, facial colliculus, corresponding to the abducent nucleus (**16′**) crossed by the fibers of the facial nerve (**16″**); **17**, pontine vestibular area, corresponding to the vestibular nuclei (**17′**)

Inferior (medullary) triangle (**A**): **10**, hypoglossal trigone corresponding to the hypoglossal nucleus (**10′**) and nucleus intercalatus (**10″**); **11**, vagal trigone (fovea inferior) corresponding to the dorsal motor vagal nucleus (**11′**) and the nucleus of the solitary tract (**11″**); **12**, medullary vestibular area corresponding to the vestibular nuclei (**12′**); **13**, area postrema (see Fig. 10) overlying the lower part of the vagal trigone; **14**, funiculus separans (a thickening of ependyma) bordering the area postrema; **14′**, interfunicular commissure; **15**, ligula (medullary insertion of the membrana tectoria). The posterior ligula (visible on this posterior view of the medulla) is linked (**15′**) to that of the opposite side on the obex. The anterior ligula prolongs the posterior ligula around the inferior cerebellar peduncle and is visible on an anterior view of the medulla (see Fig. 7)

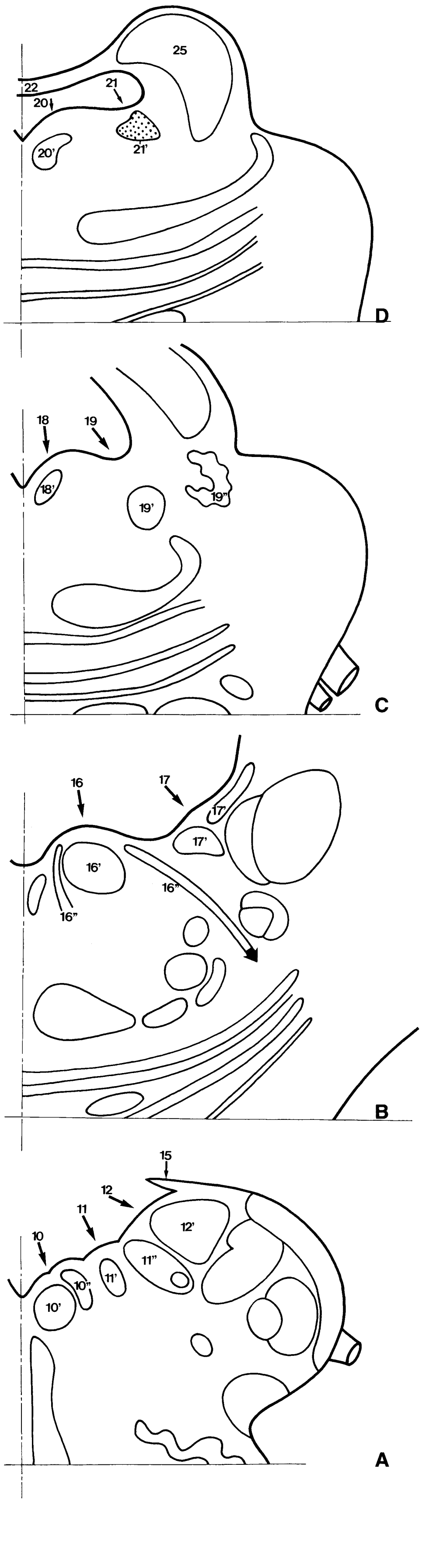


Fig. 9c (A–D)

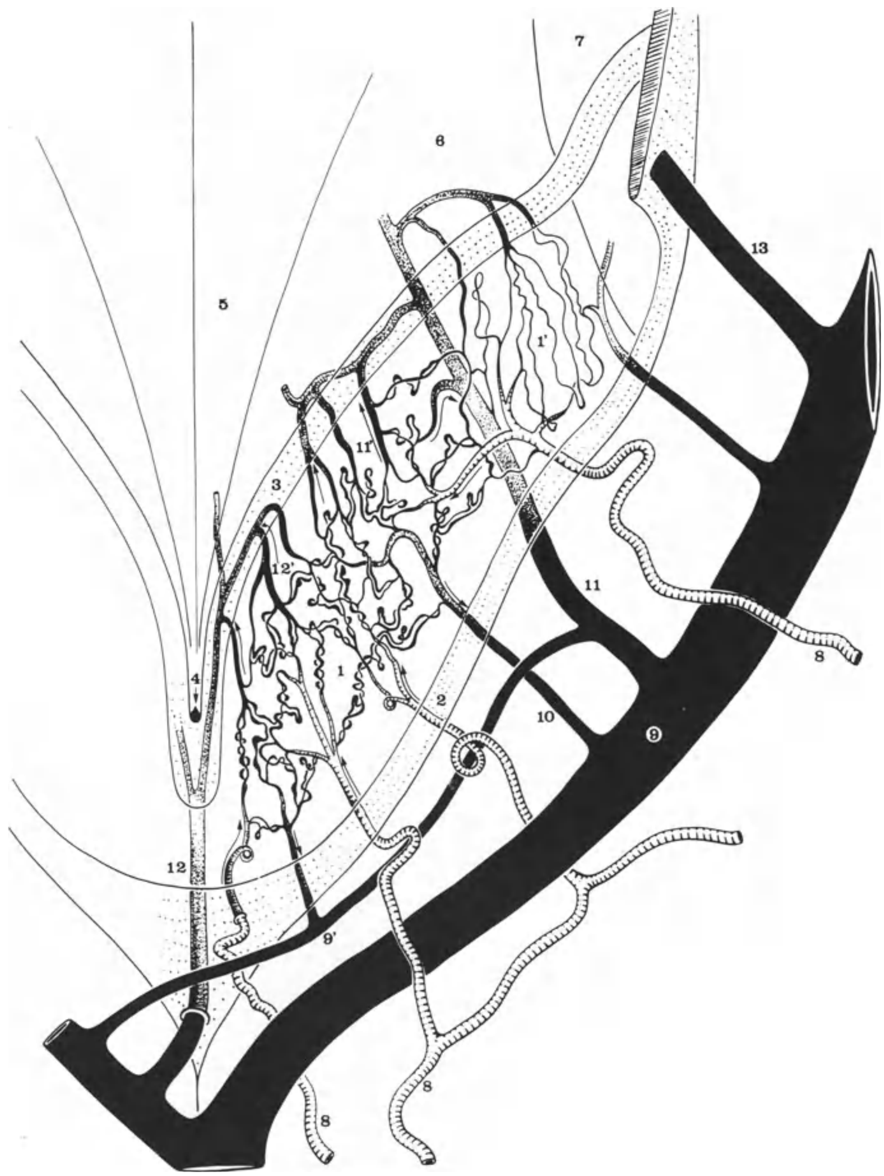


Fig. 10a–c Vascularization of the Area Postrema (drawing and vascular india ink injections)

The area postrema belongs to the group of circumventricular organs (see McKinley and Oldfield 1990) and forms, with the subjacent nucleus of the solitary tract and the dorsal motor vagal nucleus, the dorsomedial medulla with autonomic functions (see Fig. 100). The vascular network of the area postrema (1) has the characteristic aspect of those of the circumventricular organs: the capillaries are dense, irregular and sinusoid. They present numerous capillary loop formations. Their walls, devoid of the blood brain barrier, allow exchanges between blood and surrounding nervous tissue (1′ the lateral part of the area postrema is supplied by thin and rare capillaries). The arteries of the area postrema (8) are mainly branches of the posterior inferior cerebellar artery and the veins flow into the internal lateral posterior medullary veins (11) and the internal median posterior medullary vein (vein of the obex, 12). These veins reach the marginal vein of the ventricular floor (9). (9′ is an accessory marginal vein). (For more information see Duvernoy et al. 1972).

1, Area postrema; **2**, toenia of the fourth ventricle (posterior ligula); **3**, funiculus separans; **4**, central canal; **5**, hypoglossal trigone; **6**, vagal trigone; **7**, vestibular area; **8**, arterial supply; **9**, marginal vein of the floor of the fourth ventricle; **9′**, accessory marginal vein; **10**, venous drainage; **11**, internal lateral posterior medullary vein; **12**, internal median posterior medullary vein; **13**, vein of the choroid plexus

Fig. 10b. Bar, 0.8 mm

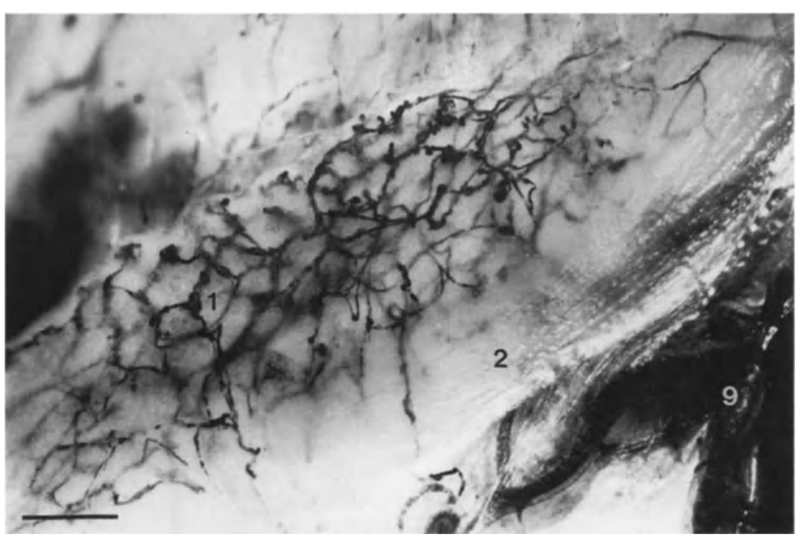


Fig. 10c. Bar, 0.7 mm

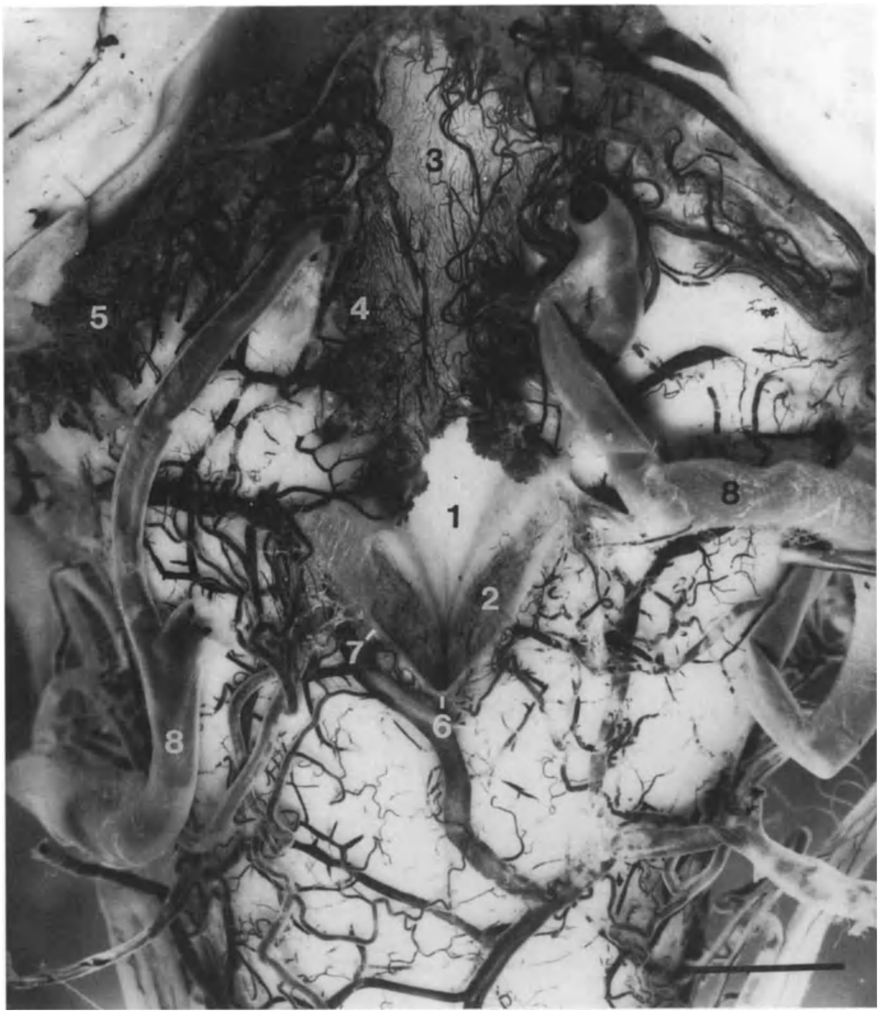


Fig. 11. Posterior View of the Medulla After Partial Removal of the Cerebellum. **Bar, 3.4 mm**

1, Median aperture (foramen of Magendie) (through the median aperture, the ventricular floor and the area postrema **2**, are visible); **3**, membrana tectoria; **4**, intraventricular choroid plexuses seen in transparency; **5**, lateral extension of the choroid plexus in the lateral aperture (extraventricular choroid plexuses, see Fig. 7); **6**, obex; **7**, toenia of fourth ventricle (posterior ligula; see in Fig. 7 its continuation to the anterior ligula); **8**, posterior inferior cerebellar artery

Figures 11 and 12 show the median and lateral apertures of the fourth ventricle.

Fig. 12. Transverse Section of the Medulla and Cerebellum (Vascular india ink injection.) Bar, 3.7 mm

1, Lateral aperture (of Luschka); 2, extraventricular choroid plexuses (see Fig. 7); 3, Intraventricular choroid plexuses; 4, ventricular cavity; 5, tonsil; 6, inferior medullary velum; 7, flocculus; 8, inferior cerebellar peduncle; 9, vagus nerve; 10, anterior ligula covered by the vagus or glossopharyngeal nerves, according to the section level (see Fig. 7); 11, inferior olive; 12, lateral medullary fossa

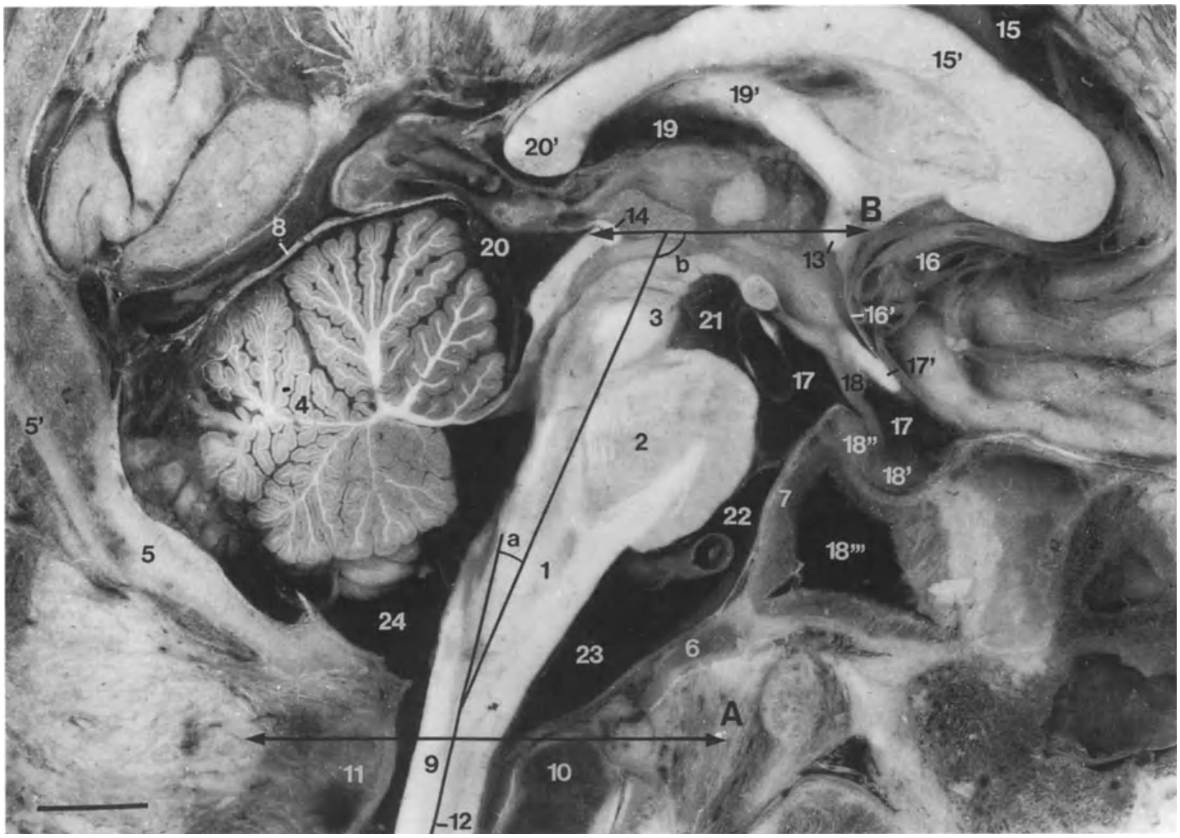


Fig. 13. Median Section of the Head (showing the relationships of the brain stem with the cerebellum and the subarachnoid spaces). **Bar, 13 mm**

The medulla (**1**), pons (**2**), mesencephalon (**3**), and cerebellum (**4**) are located within the *posterior cranial fossa*, which is closed dorsally by the occipital squama (**5**); (**5'** external occipital protuberance), ventrally by the basilar parts of occipital (**6**) and sphenoid (**7**), and superiorly by the tentorium cerebelli (**8**). The mesencephalon (3) reaches the middle cranial fossa through the tentorial opening (see Duvernoy 1995). The limit between spinal cord (**9**) and medulla (**1**) is an arbitrary plane (*A*) passing ventrally through the superior apex of the dens of the axis (**10**), and dorsally through the middle of the atlas posterior arch (**11**)

Position of the brain stem: with the axis of the spinal cord (**12**) the axis of the brain stem forms an average angle (**a**) of 15°. This axis forms an average angle (**b**) of 110° to 130° with the bicommissural plane (**B**), which links the anterior (**13**) to the posterior (**14**) commissures

Subarachnoid cisterns: the subarachnoid cisterns are enlargements of the subarachnoid spaces due to the disparity between the nervous structures and the skull. They are divided into supra- and infratentorial cisterns (for more information about subarachnoid cisterns see Liliequist 1959; Yasargil 1984; Duvernoy 1995)

Supratentorial cisterns: 15, supracallosal cistern (**15'** corpus callosum); **16**, cistern of the lamina terminalis (**16'** lamina terminalis); **17**, chiasmatic cistern (also called perihypophysial cistern) (**17'** optic chiasma) situated around the hypophysial stalk (**18**) (**18'** anterior, **18"** posterior lobes of the hypophysis, **18'''** sphenoidal sinus); **19**, cistern of the velum interpositum (median part of the transverse fissure situated under the fornix, **19'**); **20**, quadrigeminal cistern in relation to the pineal and collicular regions and covered by the splenium of the corpus callosum (**20'**); **21**, the interpeduncular cistern is linked to the quadrigeminal cistern by the crural and ambient cisterns situated around the mesencephalon (Fig. 14)

Infratentorial cisterns: due to the tentorial opening, the quadrigeminal cistern (**20**) belongs to both the supra- and infratentorial cisterns.; **22**, prepontine cistern; laterally continuous with the cistern of the cerebellopontine angle.;
23, premedullary cistern; **24**, cerebellomedullary cistern (cisterna magna)

Fig. 14. Horizontal (Axial) Section of the Mesencephalon
Superior aspect of the section. **Bar, 10 mm**

Perimesencephalic cisterns: **1**, interpeduncular (intercrural) cistern; **2**, crural cistern lining the crus cerebri (2′); **3**, ambient cistern in relation to the lateral surface of the mesencephalon; **3′**, wing of ambient cistern; the ambient cistern and its wing form the lateral part of the transverse fissure; **4**, quadrigeminal cistern covering the colliculi. **5**, Cerebral aqueduct; **6**, tectum of the mesencephalon; **7**, tegmentum of the mesencephalon; **8**, substantia nigra; **9**, superior vermis; **10**, tentorium cerebelli; **11**, hippocampal body: gyrus dentatus; **11′**, Hippocampal body: cornu ammonis; **12**, hippocampal head: hippocampal digitations which protrude into the temporal horn; **13**, uncal part of hippocampus (for more information about the hippocampal anatomy see Duvernoy 1998); **14**, amygdala; **15**, mamillary body; **16**, tuber cinereum; **17**, infundibular recess of the third ventricle; **18**, optic tract; **19**, lamina terminalis and suprachiasmatic recess
Basal cisterns: **20**, chiasmatic (perihypophysial) cistern; **21**, cistern of the lamina terminalis; **22**, carotid cistern; **23**, sylvian cistern

PART I

Arteries and Veins of the Brain Stem

General Arrangement of the Superficial Arteries and Veins of the Brain Stem

Before studying the regional vascular anatomy of the brain stem, an overall view of its vascularization is described in Figs. 15–19. These figures may be used as a guide for the subsequent and more precise description of superficial paths and internal territories of arteries and veins studied together, which can be seen in pages 32–59 and in Figs. 20–33 with following vascular injections (Figs. 34–93).

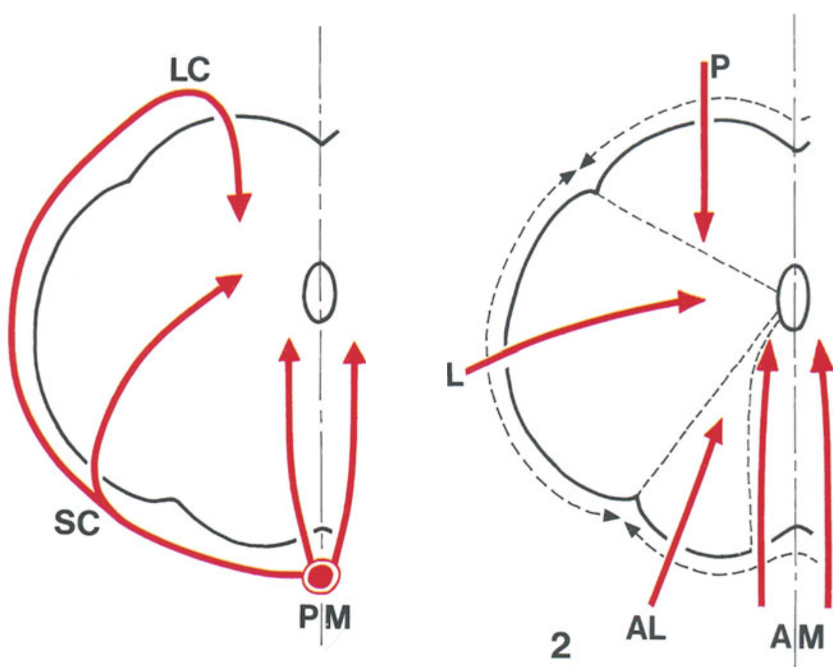


Fig. 15. The two drawings 1 and 2 show the different possibilities in terminology used to describe the blood vessels supplying the brain stem. 1: In the most widespread classification (Foix and Hillemand, 1925 c), the brain stem arteries arising from the main arterial trunks are divided into: *PM*, paramedian; *SC*, short circumferential; *LC*, long circumferential arteries. 2: The classification of Gillilan (1964) and Lazorthes et al. (1976), used in this work, is based on the point of penetration of arteries (and emergence of veins) according to the anterior, lateral, and posterior brain stem surfaces. *A*, the anterior group of arteries and veins is subdivided into anteromedial (*AM*) and anterolateral (*AL*)
L, lateral group; *P*, posterior group
The dotted lines delineate their corresponding internal territories

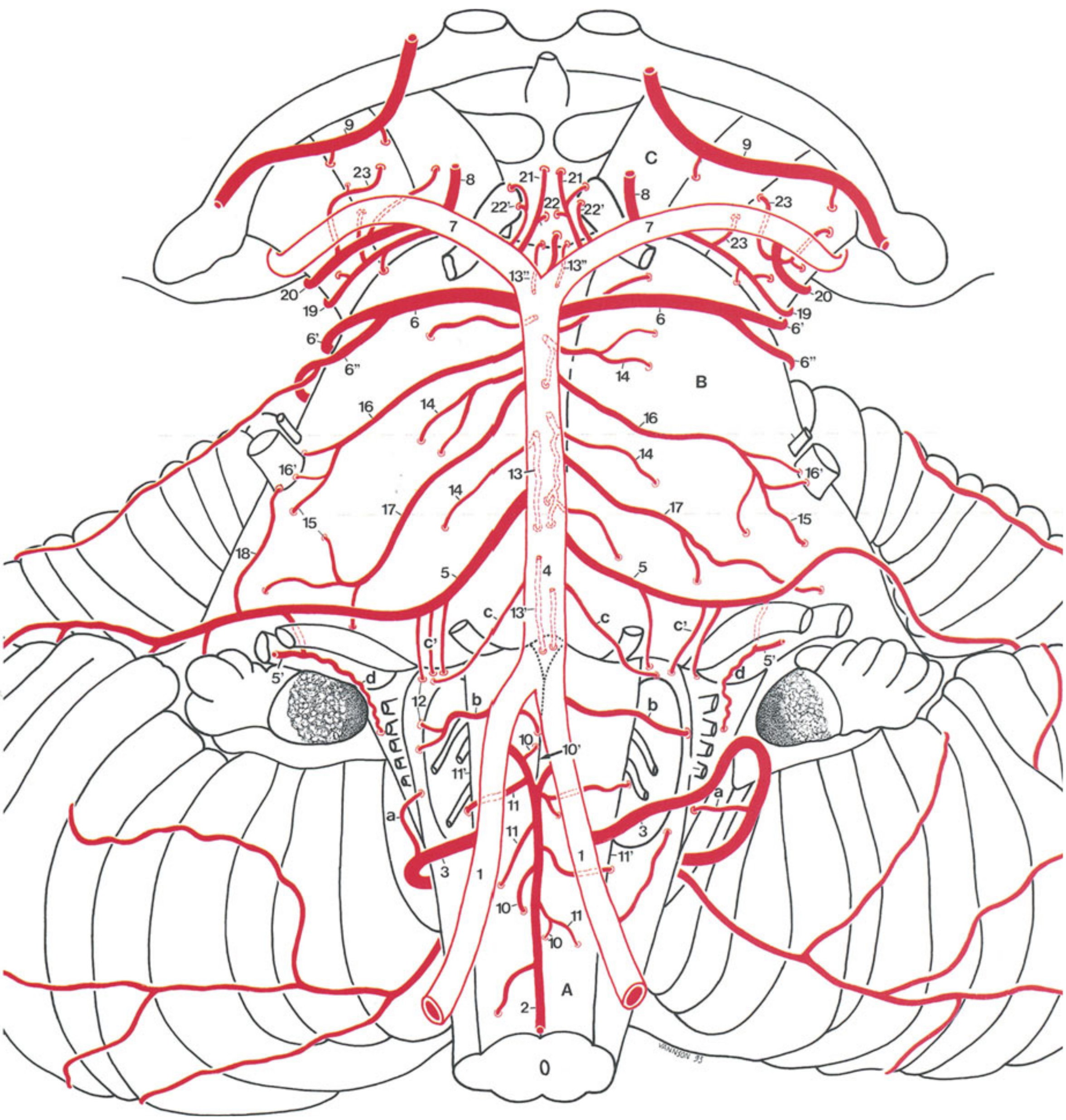


Fig. 16. Anterior view showing the general arrangement in the brain stem arteries. *A*, medulla; *B*, pons; *C*, mesencephalon

The arteries of the brain stem arise from the following main arterial trunks: **1**, vertebral arteries; **2**, anterior spinal artery; **3**, posterior inferior cerebellar arteries (PICA) (note their variable path to reach the posterior medullary surface); **4**, basilar artery; **5**, anterior inferior cerebellar arteries (AICA); **5'**, internal auditory arteries; **6**, superior cerebellar arteries (SCA); **6'**, **6"**, medial and lateral branches of the superior cerebellar arteries; **7**, posterior cerebral arteries; **8**, posterior communicating arteries; **9**, anterior choroidal arteries. The brain stem arteries arising from the main trunks are divided into *anteromedial, anterolateral, lateral,* and *posterior groups* according to their point of penetration in the different surfaces of the brain stem (see Fig. 15). Arteries of medulla, pons, and mesencephalon will be successively studied

Arteries of the medulla: 10, *anteromedial group of medullary arteries.* Arising from the anterior spinal and vertebral arteries, these arteries penetrate in the anteromedian medullary sulcus (**10'**). **11**, *Anterolateral group of medullary arteries.* Arising from the anteromedial group, these arteries, enter the pyramid and the anterolateral (preolivary) sulcus (**11'**).
12, *Lateral group of medullary arteries.* These arteries penetrate in the lateral medullary fossa (arteries of the lateral medullary fossa). The arteries of the lateral medullary fossa may be, in most cases, divided into four groups of rami:

(Contin. see page 29)

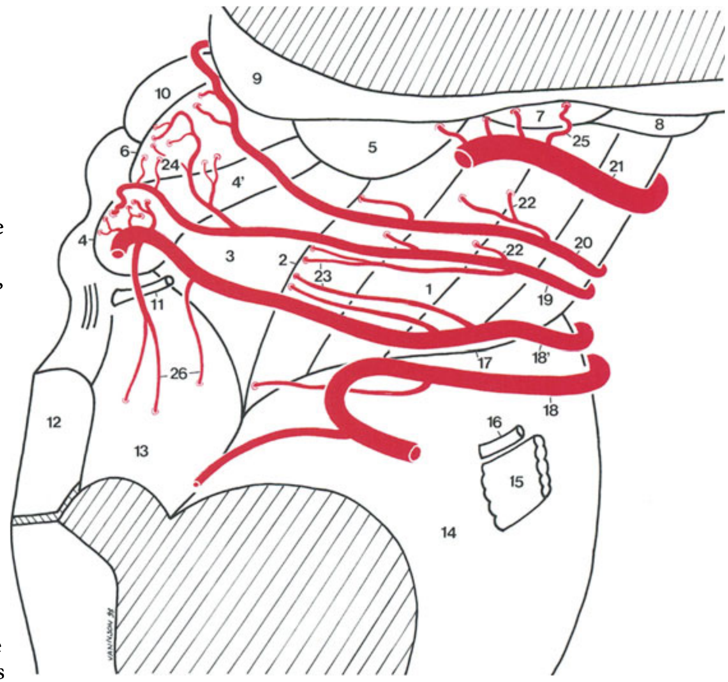


Fig. 17. Right lateral view showing the pontine and mesencephalic arteries
1, crus cerebri; **2**, lateral mesencephalic sulcus; **3**, lateral surface of the mesencephalon; **4**, inferior colliculus; **4′**, inferior collicular brachium; **5**, medial geniculate body; **6**, superior colliculus; **7**, lateral geniculate body; **8**, optic tract; **9**, pulvinar; **10**, pineal gland; **11**, trochlear nerve; **12**, superior medullary velum; **13**, superior cerebellar peduncle (brachium conjunctivum); **14**, middle cerebellar peduncle (brachium pontis); **15**, trigeminal nerve, sensory root; **16**, trigeminal nerve, motor root; **17**, pontomesencephalic sulcus.
Five arterial trunks give rise to the arteries supplying the mesencephalon, in ascending order: **18**, superior cerebellar artery, lateral branch; **18′**, superior cerebellar artery, medial branch; **19**, collicular (quadrigeminal) artery; **20**, medial posterior choroidal artery; **21**, posterior cerebral artery
Mesencephalic arteries: 22, *the anterolateral group of mesencephalic arteries* studied in the ventral view (Fig. 16), is also visible in a lateral view of the crus cerebri. The anterolateral group of mesencephalic arteries mainly arises from the collicular and medial posterior choroidal arteries (see Fig. 20 for more details). **23**, *The lateral group of mesencephalic* arteries is composed of branches arising from the medial and lateral superior cerebellar, collicular and medial posterior choroidal, arteries. They mainly enter the lateral mesencephalic sulcus (**2**). **24**, *Posterior group of mesencephalic arteries* forms a dense network covering the colliculi and is composed of branches arising from the medial superior cerebellar, collicular and medial posterior choroidal arteries (see Fig. 21). **25**, The thalamogeniculate arteries, supplying the thalamus, mainly arise from the posterior cerebral artery.
Pontine arteries: 26, *the posterior group of pontine arteries* arises from the medial and lateral superior cerebellar arteries and supplies the superior cerebellar peduncle (brachium conjunctivum)

(Contin. of p. 28, Fig. 16)
a, inferior rami, arising from the posterior inferior cerebellar artery (*3*); *b*, middle rami, arising from the vertebral artery (*1*); superior rami, composed in two distinct groups: *c*, arising from the initial segment of the basilar artery (*4*) and supplying the upper medullary level. *c'*, Arising from the anterior inferior cerebellar artery (*5*) and supplying the lowest pontine tegmentum (see Figs. 28a and d). *d*, Posterior rami arising from the anterior inferior cerebellar artery and entering the nervous tissue posterior to the glossopharyngeal and vagus nerves. *The posterior group of medullary arteries* is hidden on this anterior view and will be described in Figs. 21 and 46. The vessels of this group arise from the posterior inferior cerebellar arteries, and from the posterior spinal arteries
Arteries of the pons: *anteromedial group of pontine arteries*, branching from the basilar artery, enters in the basilar sulcus for the middle arteries (**13**), in the foramen caoecum (**13′**) for the inferior arteries, and in the interpeduncular fossa (**13″**) for the superior arteries (inferior pedicle of the arteries of the interpeduncular fossa) (see Fig. 28d to follow their deep path). **14**, *Anterolateral group of pontine arteries:* arising from the basilar artery, these arteries penetrate the anterior surface of the pons. **15**, *Lateral group of pontine arteries:* these arteries arise from two origins: – either from the lateral pontine arteries:, – two lateral pontine arteries are usually found: the superior lateral pontine artery (**16**) whose branches enter the trigeminal nerve emergence (**16′**), and the inferior lateral pontine artery (**17**) whose branches supply the middle cerebellar peduncle (lateral pontine surface); – or from the anterior inferior cerebellar artery for the middle cerebellar peduncle (**18**). *The posterior group of pontine arteries*, hidden on this anterior view (see Fig. 17), vascularizes the superior cerebellar peduncle (brachium conjunctivum). These arteries arise from the medial and lateral branches of the superior cerebellar artery
Arteries of the mesencephalon: these arteries arise from arterial trunks which curve round the mesencephalon and are, in ascending order, the superior cerebellar (*6*) (medial (*6'*) and lateral branches (*6"*)), collicular (**19**), medial posterior choroidal (**20**), posterior cerebral (*7*) and anterior choroidal (*9*) arteries (see Figs. 17 and 32d). *The anteromedial group of mesencephalic arteries* belongs to the arteries of the interpeduncular fossa. The arteries of the interpeduncular fossa (see p. 51) are frequently divided into three pedicles: superior (thalamo perforating arteries) supplying the thalamus (**21**); inferior supplying the pons (*13"*); intermediate which constitutes the anteromedial group of mesencephalic arteries subdivided into a median (**22**) and right and left (**22′**) groups of rami. **23**, *Anterolateral group of mesencephalic arteries* arising from the arterial trunks circling the mesencephalon

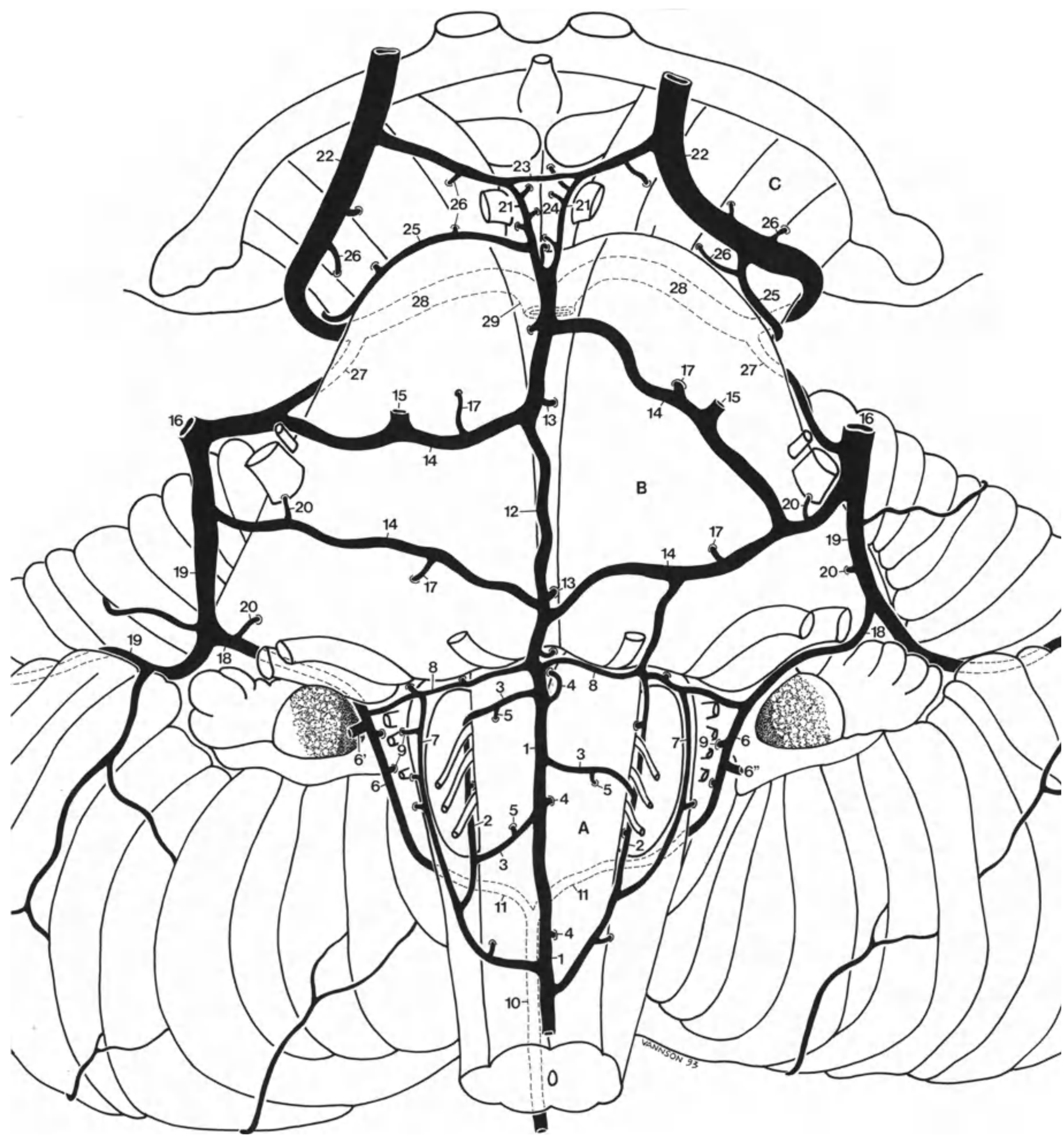


Fig. 18. Anterior view showing the general arrangement of the brain stem veins. *A* medulla; *B* pons ; *C* mesencephalon. The path of the brain stem veins is quite different from that of the brain stem arteries. The superficial venous trunks together compose a cross-ruled network formed by longitudinal and transverse veins. Their drainage into the venous sinuses is variable and this drawing shows the most common features. The superficial venous trunks drain the deep veins which emerge from the nervous tissue. These veins will be divided, as for the arteries, into anteromedial, anterolateral, lateral, and posterior groups (for more informations about the veins of the brain stem see DUVERNOY, (1975) and MATSUSHIMA et al., (1983))

Veins of the medulla – *anterior surface:* **1**, median anterior medullary vein; **2**, lateral anterior (preolivary) medullary vein; **3**, transverse medullary veins. The median anterior vein drains the *anteromedial group of medullary veins* (**4**). The lateral anterior and transverse veins drain the *anterolateral group of medullary veins* (**5**). *Lateral surface:* **6**, lateral medullary vein situated behind the glossopharyngeal and vagus nerve roots; **6'**, drainage by a bridging vein toward the inferior petrosal sinus; **6"**, drainage by a bridging vein towards the sigmoid sinus; **7**, retro-olivary vein; **8**, vein of the pontomedullary sulcus. These veins together receive *the lateral group of medullary veins* (**9**) (veins of the lateral medullary fossa). *Posterior surface:* the veins of the posterior surface of the medulla are seen in transparency (see Fig. 19 for more details). **10**, Median posterior medullary vein; **11**, marginal vein of the ventricular floor draining into the lateral medullary vein (**6**) (Contin. see p. 31)

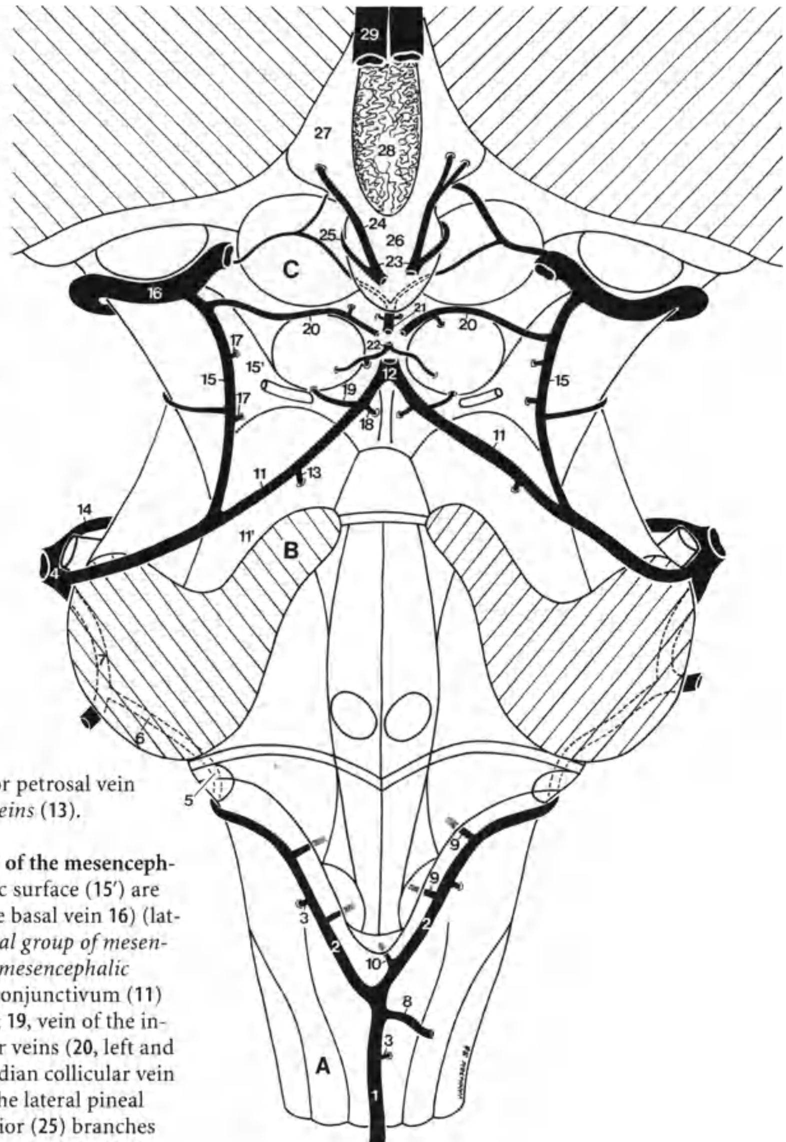


Fig. 19. Posterior view of the brain stem showing the general arrangement of the posterior brain stem veins. *A*, Medulla; *B*, pons; *C*, mesencephalon
Veins of the posterior surface of the medulla: **1**, posterior median medullary vein; **2**, marginal vein of the ventricular floor (vein of the inferior cerebellar peduncle). The marginal vein and the posterior medullary vein which receive the *posterior group of medullary veins* (**3**) are often drained towards the superior petrosal vein (**4**) successively through the lateral medullary (**5**) lateral pontine (**6**) and anterior cerebellar (**7**) veins (see Fig. 18). **8** shows occasional drainage of the posterior venous medullary network by a bridging vein (vein of the cerebellomedullary cistern) towards the marginal sinus (bordering the foramen magnum) or towards the occipital sinus. The internal lateral (**9**) and median posterior (**10**) medullary veins drain the floor of the fourth ventricle (subependymal veins)
Veins of the posterior surface of the pons: **11**, the veins of the brachia conjunctiva (veins of the superior cerebellar peduncles) (**11'**) which, on each side, link the precentral vein (**12**) to the superior petrosal vein (**4**) *receive the posterior group of pontine veins* (**13**).
14, Transverse pontine vein (see Fig. 18)
Veins of the lateral and posterior surfaces of the mesencephalon: the veins of the lateral mesencephalic surface (**15'**) are the lateral mesencephalic vein (**15**) and the basal vein **16**) (laterodorsal segment). They receive the *lateral group of mesencephalic veins (***17**). *The posterior group of mesencephalic veins* flows into the vein of the brachium conjunctivum (**11**) (**18**, vein of the recess of the frenulum veli; **19**, vein of the infracollicular recess), and into the collicular veins (**20**, left and right intercollicular veins; **21**, superior median collicular vein and **22**, inferior median collicular vein). The lateral pineal veins (**23**) drain by superior (**24**) and inferior (**25**) branches the pineal gland (**26**) and the habenular trigone (**27**). **28**, Suprapineal recess; **29**, internal cerebral vein

(Contin. of p. 20, Fig. 18)
Veins of the pons – *anterior surface:* **12**, the median anterior pontine vein, drained upwards into the right and left interpeduncular veins (*21*), is often called the pontomesencephalic vein. The median anterior pontine vein drains the *anteromedial group of pontine veins* (**13**). **14**, Transverse pontine veins drained into the basilar plexus (**15**) and into the superior petrosal vein (**16**). The transverse pontine veins receive the *anterolateral group of pontine veins* (**17**). *Lateral surface:* **18**, lateral pontine vein. It receives the lateral medullary vein (*6*) and is drained into the anterior cerebellar vein (**19**) which is a tributary of the superior petrosal vein (*16*); The transverse and lateral pontine veins drain the *lateral group of pontine veins* (**20**). *Posterior surface:* the veins of the posterior pontine surface (veins of the superior cerebellar peduncles or veins of the brachia conjunctiva) are shown in Fig. 19

Veins of the Mesencephalon: *interpeduncular fossa.* **21**, Interpeduncular vein draining the anterior median pontine vein and reaching the basal vein (**22**). The right and left interpeduncular veins drain the *anteromedial group of mesencephalic veins* (**24**) (veins of the interpeduncular fossa). **23**, Posterior communicating vein; *mesencephalon anterior aspect* (crus cerebri); **22**, basal vein (ventral segment) (for the description of the basal vein, see Figs. 67–74); **25**, vein of the pontomesencephalic sulcus. The basal and interpeduncular veins and the vein of the pontomesencephalic sulcus together drain the *anterolateral group of mesencephalic veins* (**26**). *Lateral and posterior aspects:* described in Fig. 19, these veins are visible in transparency. **27**, Lateral mesencephalic vein; **28**, basal vein (laterodorsal segment); **29**, great cerebral vein (of Galen)

Superficial Path and Internal Territories of Arteries and Veins of Medulla, Pons and Mesencephalon

Medulla

A. Superficial Arteries and Veins of the Medulla

(Figs. 15, 16, 18–21, 24–27 and 34–51; sections I–IV)

The superficial arteries and veins of the medulla can be divided into three groups: anterior (subdivided into anteromedial and anterolateral), lateral and posterior, corresponding to the anterior, lateral and posterior surfaces of the medulla (see Figs. 2–4).

I. Anterior Groups of Medullary Arteries and Veins

a) Arteries

Anteromedial Group of Medullary Arteries (Figs. 16, 20, 35–37)

The anteromedial medullary arteries are situated on the anteromedian sulcus. They pursue characteristically sinuous courses. There is a clear difference between the superior and inferior parts of the anterior surface of the medulla (Duret, 1873; Foix and Hillemand 1925 c): in the inferior (caudal) half (Figs. 24 and25, sections I and II) the anteromedial arteries arise from the anterior spinal artery; they are few in number and small in calibre. In the superior (cranial) half, on the other hand, (Fig. 26 and27, sections III and IV), the anteromedial arteries arise from the left and right rami, which later form the trunk of the anterior spinal artery, and also from the terminal segments of the vertebral arteries. The arteries in the superior half are large and numerous, forming a dense arterial network covering the superior part of the anteromedian sulcus and the foramen caecum (Mahmood et al. 1991).

The separate arteries of the anteromedian group often anastomose both on the superior and in the inferior parts of the anterior surface of the medulla. The number of these anastomoses varies considerably from one medulla to another, some having no anastomotic links.

Anterolateral Group of Medullary Arteries (Figs. 16, 20, 36 and 37)

These arteries (described by Stopford 1916 a) arise from the anteromedial group and cross the pyramids, often to the anterolateral (or preolivary) sulcus, where their point of penetration is often hidden by the roots of the hypoglossal nerve. Some anterolateral arteries go beyond the anterolateral sulcus, reaching the olive and even the postolivary sulcus (Figs. 20 and 25, section II). In this case, they supply the lateral surface of the medulla and belong to the lateral group of arteries but their contribution to the vascularization of this region is extremely small. Occasionally, on the other hand, some arteries of the lateral group extend to the preolivary sulcus and thus belong to the anterolateral group. The anterolateral arteries meander across the pyramids in long courses and give rise to small branches which penetrate the pyramids.

Unlike the anteromedian group of arteries, the anterolateral arteries do not anastomose with each other: in rare instances, when these arteries go beyond the olive, they anastomose with the arteries of the lateral group.

b) Veins

Anteromedian Group of Medullary Veins

The anteromedian group of medullary veins (Figs. 18, 20 and 38) is hidden under the anteromedial arteries. The anteromedial group of medullary veins is drained into the median anterior medullary vein which is situated on the corresponding sulcus.

Anterolateral Group of Medullary Veins

The anterolateral group of medullary veins (Figs. 18, 20, 38) reaches the lateral anterior medullary vein which runs along the preolivary sulcus, partly hidden by the roots of the hypoglossal nerve, and the transverse medullary veins which cross the pyramids. Superior, middle and inferior transverse veins are usually found, the inferior transverse vein usually being large in calibre.

Unlike the arteries, the veins of the medullary surface are direct and relatively straight (KORITKE et al. 1970)

II. Lateral Groups of Medullary Arteries and Veins

The most densely vascularized area of the lateral surface is a hollow, situated posterior to the olive and containing numerous veins and arteries. This region has been given many different names: lateral medullary fossa, lateral medullary region, lateral para-olivary area. It is bounded by the lower margin of the pons with the roots of the facial and vestibulocochlear nerves, by the cerebellum and the lateral recess of the fourth ventricle, and by the inferior olive (Figs. 2, 6 and 7). From the floor of the lateral medullary fossa, the roots of the accessory, glossopharyngeal and vagus nerves emerge in ascending order.

a) Arteries

Lateral Group of Medullary Arteries
(Figs. 18, 20, 40–42)

The lateral group of arteries (short circumferential arteries, FOIX and HILLEMAND 1925 c) mainly consist of the arteries of the lateral medullary fossa. The arteries of the lateral medulla fossa can be divided into four groups of rami according to their position in relation to the roots of the glossopharyngeal and vagus nerves.

The inferior rami are inferior to the roots of the nerves, the middle rami are medial to the roots of the nerves, the superior rami are near the pontomedullary sulcus and the posterior rami are lateral to the glossopharyngeal and vagus nerves. There are few existing detailed descriptions of the arteries of this region, with the exception of those of ALEXANDER and SUH (1937), BÖHNE (1927), whose use of the term „olivary arteries" to describe these rami seems quite unsuitable, and SALAMON and HUANG (1976).

Inferior Rami

These rami arise directly from the vertebral artery or from the posterior inferior cerebellar artery. These small rami penetrate the medulla in groups; some reach the inferior pole of the olive, others reach the inferior cerebellar peduncle after running between the roots of the accessory nerve.

Middle Rami

The middle rami, the most important of the four groups of rami, enter the lateral medullary fossa medial to the glossopharyngeal and vagus nerves. These rami consist of one to three arteries branching directly from the vertebral artery and, in some cases, from the posterior inferior cerebellar artery. Some branches of these rami reach the olive and some even extend beyond it to penetrate the nervous tissue in the anterolateral medullary sulcus, thus forming part of the anterolateral group of arteries. The middle rami are themselves joined by rami arising from arteries of the anterolateral group. When the course of the posterior inferior cerebellar artery is only in the lower part of the lateral medullary fossa, it gives rise to branches of the inferior rami; when its course is superior to this, its branches form part of the middle rami (Fig. 42).

Superior Rami

These rami are composed of two distinct groups of arteries:

The first group comprises arteries similar in calibre to those of the middle rami and arising from the initial segment of the basilar artery. They cross the roots of the abducent nerve and then follow the pontomedullary sulcus to the upper part of the lateral medullary fossa.

The second group consists of several small arteries arising from the anterior inferior cerebellar artery on the anterior surface of the pons. These small arteries run parallel to each other in a vertical course to the superior part of the lateral medullary fossa.

These two groups of arteries penetrate the nervous tissue at the sides of the pontomedullary sulcus; the branches of the anterior inferior cerebellar artery penetrating the pons (see p. 40), those of the basilar artery penetrating the medulla.

Posterior Rami

These rami are constant but vary in size. Their branches penetrate the medulla lateral to the glossopharyngeal and vagus nerves. They are rami of a small arterial trunk which itself is a branch of the anterior inferior cerebellar artery during its path across the middle cerebellar peduncle. This small arterial trunk is characteristically spiral, its numerous turns partly obscuring the lateral medullary vein; it usually passes between the vestibulocochlear and facial nerves to the lateral medullary fossa, lateral to the roots of the glossopharyngeal and vagus nerves. These nerves must be cut away to follow the terminal segment of the vessel which is situated in a narrow fissure between the roots of the nerves and the lateral recess of the fourth ventricle.

Numerous anastomoses exist between the arteries of the different groups of rami, but their number and size vary from one subject to another. The most important anastomoses are those linking the posterior group of rami to the middle, superior and inferior groups (Atkinson 1949). As has already been mentioned, anastomoses sometimes occur between the lateral and anterior groups on the surface of the olive.

To summarize, the arteries of the lateral medullary fossa arise mainly from the vertebral artery and from the initial segment of the basilar artery. This conclusion confirms the reports of Baker (1961) and Stephens and Stilwell (1969) who rejected the classical descriptions which ascribe the predominant role to the posterior inferior cerebellar artery in the vascularization of the lateral medullary fossa. The medullary territory supplied by this artery varies considerably according to its situation: it is important if the posterior inferior cerebellar artery has an upper curve and sometimes nil if the arterial curve involves only the inferior part of the lateral medullary fossa (in 50% of the cases, Escourolle et al. 1976). It is important to note that the lateral medullary fossa is supplied by a large number of small arteries and not just by one or two as described by Foix and Hillemand (1925 c) and Foix et al. (1925).

b) Veins

Lateral Group of Medullary Veins
(Figs. 18, 20, 43, 44, 45)
This group of veins reaches the superficial veins of the lateral medullary fossa which are relatively straight and may be classified as longitudinal and transverse. The longitudinal veins are medial (retro-olivary vein) or lateral (lateral medullary vein) to the roots of the nerves. The transverse vein is the vein of the pontomedullary sulcus which, together with the retro-olivary vein, flows into the lateral medullary vein. The latter leaves the lateral medullary fossa, passing between the vestibulocochlear and facial nerves or round both of them, either laterally or medially. This vein continues along the middle cerebellar peduncle, where it is called the lateral pontine vein. The numerous variant paths of the veins of the lateral medullary fossa are described in detail in Duvernoy (1975).

Unlike the lateral medullary fossa, which is densely vascularized, the rest of the lateral surface, situated near the posterior surface, is poorly vascularized. The few veins and arteries found there will be described together with those of the medullary posterior surface.

III. Posterior Groups of Medullary Arteries and Veins

In the inferior or caudal part of the medulla (Fig. 3), the left and right posterolateral sulci form clearly defined margins for the posterior surface; the posteromedian medullary sulcus runs between the left and right gracile tubercles.

The superior (cranial) part of the posterior surface of the medulla is dominated by the fourth ventricle; the remaining part of this surface, together with the lateral surfaces, forms the inferior cerebellar peduncle (restiform body).

a) Arteries

Posterior Group of Medullary Arteries
(Figs. 21 and 46)
The arteries of this group are branches of the posterior spinal and posterior inferior cerebellar arteries. Their own branches have numerous anastomoses, situated along the posterolateral sulci. The posteromedian sulcus is almost devoid of arteries, unlike the anteromedian sulcus. This arrangement of the superficial arteries of the medulla is thus similar to that of the spinal cord (for more information concerning the arterial supply of the posterior and lateral surface of the medulla, see Lasjaunias et al. 1985 and Maillot and Koritke 1970). A few small rami arise from the arteries of the posterolateral sulci; they cross the posterior funiculi, some reaching the posteromedian sulcus.

In the superior or cranial part of the medulla, numerous branches are found along the inferior margins of the fourth ventricle. Some reach the choroid plexus, others penetrate the taenia and vascularize the floor of the ventricle.

b) Veins

Posterior Group of Medullary Veins
(Figs. 19, 21, 47–51)
The veins of this group are tributaries of the posterior superficial veins of the medulla which display a simpler arrangement than the arteries; in the inferior part of the posterior surface, there is only one vein (median posterior medullary vein) while in the superior part, this vein divides into right and left branches, which extend along the taenia of the fourth ventricle and are often called the marginal veins of the ventricular floor or veins of the inferior

cerebellar peduncles. These left and right branches cross the lateral surface of the medulla and often enter the lateral medullary vein in the lateral medullary fossa. The posterior surface is also drained in many cases by a bridging vein, the vein of the cerebellomedullary cistern (DUVERNOY 1975; Figs. 50, 51), usually a tributary of the occipital sinus situated in the attachment of the falx cerebelli or of the marginal sinus that surrounds the foramen magnum (BEBIN 1968; HACKER 1974; CAPRA and ANDERSON 1984).

B. Internal Territories of the Arteries and Veins of the Medulla

The internal territories of the anterior, lateral and posterior groups will be studied in four levels of the medulla (in caudal to cranial order: section I (Fig. 24), section II (Fig. 25), section III (Fig. 26) and section IV (Fig. 27). This detailed description will be followed by a general account of the relationship between these vascular territories and by a summary of the veins and arteries of the main tracts and nuclei of the medulla.

I. Internal Territories of the Anterior Groups of Medullary Arteries and Veins

a) Internal Territory of the Anteromedial Group of Medullary Arteries

The anteromedial medullary arteries increase in size and in number from caudal to cranial levels of the medulla (HAUW et al. 1976).

The larger long arteries are situated between the lemnisci on each side of the median line . In their courses towards their territory they often form tight bends. Their terminal rami reach the floor of the ventricle in the superior part of the medulla (Figs. 2627, sections III and IV). They supply the hypoglossal nucleus, and many of their collateral branches vascularize the medial lemniscus or run through it to supply the central reticular formation and the dorsal accessory olivary nucleus. The size and number of the arteries in and near the foramen caecum is notable (arteries of the foramen caecum, Fig. 27, section IV); they are much larger than the arteries of the inferior part. Their terminal rami encircle the hypoglossal nucleus and the nucleus praepositus. Some of the arteries of the foramen caecum reach the pontine region above it (Fig. 28, section V).

The smaller short anteromedial arteries do not reach the floor of the ventricle. Some of them follow part of the course of the larger arteries. Others run obliquely through the lemniscus to the reticular formation, also supplying the medial accessory olivary nucleus and the medial part of the inferior olivary nucleus.

b) Internal Territory of the Anteromedial Group of Medullary Veins

The internal territory of the anteromedial medullary veins is the same as that supplied by the shorter anteromedial arteries in the lower and middle levels of the medulla (Figs. 2425 and 26, sections I, II and III), rarely involving the hypoglossal nucleus. They drain only the medial lemnicus, the surrounding reticular formation and the medial part of the corticospinal tract. In the upper part of the medulla (Fig. 27, section IV), the presence of the large vein of the foramen caecum is to be noted. This principal internal anteromedial vein drains, through its left and right branches, the nuclei of the floor of the ventricle and even the reticular formation. The trunk and the branches of this vein have a characteristic „weeping willow“ appearance.

c) Internal Territory of the Anterolateral Groups of Medullary Arteries

In their path across the pyramids, the anterolateral medullary arteries supply most of the pyramids through smaller branches. The anterolateral arteries usually reach the preolivary sulcus and supply the medial part of the inferior olivary nucleus. In some cases, these arteries extend beyond the preolivary sulcus, reach the surface of the olive and supply its superficial part (Fig. 25, section II). In rare cases, some anterolateral arteries even reach the lateral medullary fossa; in this case, they are included in the lateral group of arteries and they supply the lateral part of the inferior olivary nucleus and the neighbouring reticular formation.

d) Internal Territory of the Anterolateral Groups of the Medullary Veins

The internal territory of the anterolateral medullary veins is usually the same that supplied by the arteries. The internal anterolateral medullary veins drain the corticospinal tract, and the medial and sometimes the superficial part of the inferior olivary nucleus. They end mainly in the preolivary vein (lateral anterior medullary vein) which thus drains an extremely large territory. Frequently, a central olivary vein is found draining the internal aspects of the olive and also the reticular formation and the dorsal accessory olivary nucleus (Fig. 117). This central olivary vein is usually a tributary of the preolivary vein (Fig. 25, section II).

II. Internal Territories of the Lateral Groups of Medullary Arteries and Veins

a) Internal Territory of Lateral Groups of Medullary Arteries

The superficial lateral arteries are described in four groups of the rami according to their points of entry into the brain stem in relation to the roots of the glossopharyngeal and vagus nerves. The internal territory of these lateral arteries, the obstruction of which is thought to be the cause of the lateral medullary syndrome, has been studied in detail by numerous authors (Foix and Hillemand 1925 c; Stephens and Stilwell 1969; Lazorthes et al. 1976); in most cases their descriptions are borne out by these observations.

A main feature of the internal distribution of the lateral arteries (Figs. 25 and 26, sections II and III) is that, unlike their sinuous superficial courses, the internal routes of the lateral arteries are almost straight. Two types of arteries arise from the inferior, middle and superior groups of rami: long and short.

Soon after their entry, short arteries ramify into small branches mainly supplying the tracts of the white matter (spinothalamic and ventral spinocerebellar tracts).

The initial segments of long arteries supplying the deeper regions have no branches. Some of the more important long arteries, centrally situated in relation to other long arteries, reach the floor of the fourth ventricle in the superior part of the medulla (Fig. 109), where they form part of the vascular supply of the hypoglossal and vagal nuclei, part of the nucleus of the solitary tract and even, in some cases, of the vestibular nuclei. The more laterally situated of the longer arteries reach the spinal trigeminal nucleus and neighbouring regions; the more medially situated branches vascularize the lateral part of the inferior olivary nucleus, the dorsal accessory olivary nucleus and the reticular formation.

Particular features in the internal distribution of the several groups of rami: in all cases, the branches of the inferior and middle groups ramify on the surface of the olive (Figs. 25 and 26, sections II and III). Just beyond their entry into the nervous tissue, their branches become sinuous and supply the superficial part of the inferior olivary nucleus. In some cases, they even extend beyond the olive to reach the preolivary sulcus where, together with the anterolateral arteries, they vascularize the medial part of the inferior olivary nucleus and its vicinity.

Those branches of the superior group of rami which arise from the anterior inferior cerebellar artery (Fig. 27, section IV) mainly reach the deeper regions of the pons. They penetrate the superior slope of the pontomedullary sulcus and then leave the medulla to enter the pontine tegmentum (Fig. 28, section V) (see p. 43).

The posterior rami of the lateral group vascularize quite a different region. In the inferior part of the medulla, those of its branches, which penetrate laterally near the accessory nerve, vascularize part of the inferior cerebellar peduncle, the cuneate nucleus and sometimes the spinal trigeminal nucleus. In the superior part of the medulla, the numerous branches of the posterior group of rami which enter laterally in relation to the roots of the glossopharyngeal and vagus nerves traverse divergent routes (Figs. 26 and 27, sections III and IV). Some extend laterally round the inferior cerebellar peduncle under the ependyma of the lateral ventricular recess of the fourth ventricle; these arteries supply the dorsal and ventral cochlear nuclei and also the superior part of the cuneate nucleus and the medial and inferior vestibular nuclei (Fig. 27, section IV). Others pass medially round the inferior peduncle to supply the vestibular nuclei and sometimes the spinal trigeminal nucleus.

b) Internal Territories of the Lateral Group of Medullary Veins

The lateral veins are tributaries of the retro-olivary vein, the lateral medullary vein and the vein of the pontomedullary sulcus. Like the arteries, they can be divided into four groups of rami.

Their main features are, in general, similar to those of the corresponding arteries as far as the inferior, middle and superior groups of rami are concerned (Figs. 25 and 26, sections II and III); the more centrally situated veins are larger than the laterally and medially situated veins, and their size increases regularly at more cranial levels of the medulla (Figs. 104, 108, 111). From level II upwards (Fig. 25), these centrally situated veins drain the floor of the ventricle. In particular, some of these central veins assume a predominant role and these principal lateral medullary veins drain not only the floor of the ventricle but also deeper regions through branches which curve backwards, giving the veins a weeping willow appearance. Some of these branches extend to territory situated beyond the median line (Fig. 26, section III). The medially situated veins drain the lateral part of the inferior olivary nucleus. The laterally situated veins are rare; their territory is usually drained by the veins of the posterior group of rami. Like the arteries which they accompany, the veins of the superior group of rami (Fig. 27, section IV) vascularize the deeper regions of the pontine tegmentum (Fig. 28, section V).

The veins of the posterior group of rami, often large, are tributaries of the lateral medullary vein. Like the arteries, the veins of the posterior group of rami follow two different routes (Fig. 27, section IV); some run laterally round the inferior cerebellar peduncle under the ependyma of the lateral recess of the fourth ventricle and drain the blood of the ventral and dorsal cochlear nuclei; others skirt medially round the peduncle and drain the vestibular nuclei and the spinal trigeminal nucleus.

III. Internal Territories of the Posterior Groups of Medullary Arteries and Veins

a) Internal Territories of the Posterior Group of Medullary Arteries

In the inferior or „closed" part of the medulla, below the level of the fourth ventricle (Fig. 24, section I), numerous small arteries penetrate the gracile and the cuneate tubercles to vascularize the corresponding nuclei. They also supply the inferior parts of the nucleus of the solitary tract, the vagal nucleus and sometimes the trigeminal nucleus. At intermediate medullary levels, the posterior arteries are mainly near the inferior angle of the fourth ventricle (Fig. 25, section II). These small arteries pursue a sinuous superficial route before penetrating the taenia to supply the area postrema (Duvernoy et al. 1972) and the subjacent nuclei of the vagus nerve and of the solitary tract. They also reach the medial vestibular and cuneate nuclei. In the superior or „open" part of the medulla, the arteries of the posterior group are absent (Fig. 27, section IV).

b) Internal Territories of the Posterior Group of Medullary Veins

In the inferior part of the medulla, the routes and the internal territories of the posterior group of medullary veins are very similar to those of the arteries. At intermediate medullary regions (Fig. 25 and 26, sections II and III), the internal posterior veins are very large. Three principal internal posterior veins are usually present: the left and right internal lateral posterior veins and the internal median posterior vein. They all participate in the venous drainage of the floor of the ventricle. The median posterior vein is formed by two left and right branches which drain the hypoglossal and vagal nuclei and the nucleus of the solitary tract on both sides of the median line (Fig. 24, section I). The median posterior vein thus formed can be called the vein of the obex because it flows into the superficial posterior median vein near the obex. More cranially in the medulla (Fig. 25 and 26, sections II and III), the lateral posterior veins are subjacent to the ependyma of the ventricle and enter the marginal veins of the ventricular floor; the lateral posterior veins sometimes drain a large territory, extending even to the highest level of the medulla. They drain the superior segment of the hypoglossal and vagal nuclei and of the nucleus of the solitary tract (Fig. 103).

IV. Subependymal Medullary Veins of the Floor of the Fourth Ventricle

The principal medullary veins often ramify under the ependyma (Fig. 21). Frequently, the internal principal posterior veins (median and lateral posterior veins) run under the ependyma and are tributaries of the marginal vein of the ventricular floor, some passing under the area postrema (Fig. 10).

More rarely, the ramifications of the internal principal anteromedial veins are also found under the ependyma, as are those of the lateral group. Those veins of the lateral group which drain into the posterior rami of the lateral medullary fossa are frequently subependymal in the lateral recess of the fourth ventricle, as are the arteries of the same group (Fig. 27, section IV).

V. General Survey of the Internal Territories of the Medulla

The medullary territories of the main groups of arteries and veins can be seen in the drawings accompanying section I (Fig. 24), II (Fig. 25), III (Fig. 26) and IV (Fig. 27).

a) Arterial Territories

It is interesting to note that the territories of anterior and lateral groups increase in size in the more cranial regions of the medulla. As a result, the territory of the posterior group, which in the lower part involved most of the posterior medullary nuclei, is absent above the middle region.

b) Venous Territories

In the medulla, internal principal veins, which have no equivalent arteries, often occur. This pattern is a general feature in the brain (Duvernoy et al. 1981 and 1983). In superior levels of the medulla (Fig. 27, section IV), the vein of the foramen caecum drains the left and right central medullary zone.

At intermediate levels, a principal lateral medullary vein often ramifies under the floor of the ventricle, and its territory sometimes extends beyond the median line (Fig. 26, section III).

In the more caudal regions (Figs. 24 and 25, sections I and II), the veins of the anterior group are little involved, the relative territories supplied by the posterior and lateral groups varying considerably; in some cases, the principal posterior veins preponderate since they drain all the blood from the posterior medullary nuclei; in other cases, the principal lateral veins assist in the drainage of these nuclei, and then the principal posterior veins are less extensive.

VI. Vascularization of Tracts and Nuclei in the Medulla

a) Tracts

The corticospinal tract and the medial lemniscus depend entirely on the anterior group of medullary arteries. The veins of the anterior group also preponderate in the drainage of these tracts. But the posterior part of the medial lemniscus is also drained by principal lateral and posterior veins (Figs. 25 and 26, sections II and III). The spinothalamic tract is vascularized only by the arteries and veins of the lateral group.

b) Nuclei

Unlike the tracts, the nuclei are supplied by arteries and veins of different medullary groups. The hypoglossal nucleus, which has usually been considered to depend on the anterior group, is also supplied by the lateral group of arteries (Figs. 25, 26 and 27, sections II, III and IV). Its venous drainage depends, in the cranial part of the medulla, on the anteromedial group of veins (Fig. 27, section IV) and in the caudal part ,on the principal lateral and posterior medullary veins (Fig. 24, 25 and 26, sections I, II and III).

The vagal nucleus and the nucleus of the solitary tract are vascularized in the caudal part of the medulla by the posterior group of arteries and veins(-Figs. 24 and 25, sections I and II), whereas in the intermediate and cranial parts of the medulla, these nuclei are vascularized by the lateral groups of arteries and veins (Figs. 25 and 26, sections II and III).

The vestibular nuclei are also supplied by arteries and veins belonging to different groups. In the caudal part of the medulla, they are vascularized by the posterior group (Figs. 25 and 26, sections II and III), in the cranial part, by the lateral groups (Fig. 27, section IV).

The spinal trigeminal nucleus is mainly vascularized by the lateral groups, but the arterial supply is usually provided by the inferior, middle and superior rami of the lateral group, whereas the venous drainage is usually by the posterior rami of the lateral group (Fig. 27, section IV).

Existing descriptions of the vascular supply of the inferior olivary nucleus differ considerably (Akar et al. 1995; De Smet et al. 1984). It is convenient to divide this nucleus into three parts: lateral, medial and a superficial rounded part (Figs. 25 and 26, sections II and III; Fig. 112). In the majority of cases, the medial part is mainly supplied by arteries of the anterior groups, the lateral part by arteries of the lateral group, and the superficial rounded part by arteries of both the anterior and lateral groups. This arrangement is also described by Lazorthes et al. (1976). In some medullae, the anterior group is predominant, vascularizing most of the olive (Fig. 25, section II); in others, the vascularization is mainly by the lateral group (Fig. 26, section III). The venous drainage of the inferior olivary nucleus is very similar to the arterial supply, with the exception of the frequently present central olivary vein which has no corresponding artery (Fig. 25, section II; Fig. 117). This vein drains the internal aspects of all three parts of the inferior olivary nucleus, and also the neighbouring reticular formation and the dorsal accessory olivary nucleus. It is usually a tributary of the preolivary vein and then belongs to the anterior group. More rarely, it reaches the retro-olivary vein and then belongs to the lateral group.

Pons

A. Superficial Arteries and Veins of the Pons

(Figs. 16,–21, 28–31, sections V–VIII; and Figs. 52–61)

The superficial arteries and veins of the pons can be divided into anterior, lateral and posterior groups.

I. Anterior Groups of Superficial Pontine Arteries and Veins

The anterior group of arteries and veins can be subdivided into anteromedial and anterolateral groups.

a) Arteries

Anteromedial Group of Pontine Arteries
(Figs. 16, 20 and 53)
The anteromedial pontine arteries arise from the basilar artery either directly or by trunks common to the arteries of the lateral group. There are three or four arteries on each side, as was noted by Foix and Hillemand (1925 a, 1925 c), Stephens and Stilwell (1969), Torche et al. (1992), and Marinkovic and Gibo (1993). They follow the banks of the basilar sulcus. The superficial courses of the branches arising further down the basilar artery are much longer (Foix and Hillemand, 1925 a, 1925 c). Thus, the arteries penetrating the foramen caecum are the branches with the longest routes. The branches of the anteromedial arteries are often twisted round each other before they unwind and divide into smaller branches, which penetrate the pons along the edges of the sulcus. Some branches curve back and upwards to anastomose with branches situated more cranially. In some cases, these anastomoses along the edge of the sulcus are numerous; in some cases, they are completely absent. There are few anastomotic links between the left and right anteromedial arteries across the basilar sulcus. It is to be noted that, as the basilar sulcus is wider in its superior part, the left and right anteromedial arteries, which run along the edges of the sulcus, are further apart superiorly (Foix and Hillemand, 1925 a, 1925 c). In this group of anteromedial pontine arteries, can be included some small branches of the terminal segment of the basilar artery which reach the interpeduncular fossa where they form the inferior pedicle of the interpeduncular fossa, supplying superior levels of the pontine tegmentum (Figs. 30 and 31, sections VII and VIII) (Marinkovic and Gibo, 1993).

Anterolateral Group of Pontine Arteries
(Figs. 16, 20, 53, 54 and 55)
The anterolateral pontine arteries have been described by Stopford (1916 a) and by Gillilan (1964) who called them short lateral arteries. They are small rami of the anteromedial arteries. They have a transverse path and penetrate the pons in no particular arrangement. On their superficial path, the anterolateral arteries often disappear into the nervous tissue where a deep branch arises from them; after this short incursion into the nervous tissue, they reappear on the surface. The branches of the anterolateral arteries often penetrate the nervous tissue where branches of the anterolateral veins emerge. It is notable that no anastomoses between these arterial branches were observed by us.

b) Veins

The *anteromedial* and *anterolateral* groups of *pontine veins* will be described together (Figs. 18–20, 53–60). They flow into venous trunks which make up longitudinal (median anterior pontine vein and lateral anterior pontine veins) and transverse systems (transverse pontine veins). The *median anterior pontine vein* is often a continuation of the anterior median medullary vein. It frequently displays an interrupted course. At superior pontine levels, the anterior median vein reaches the interpeduncular fossa, where it anastomoses with the left and right interpeduncular veins. The *lateral anterior pontine veins* are less easy to distinguish and not as well-defined as the corresponding lateral anterior medullary veins, except at the lower part of the pons near the emergence of the abducent nerve, where they continue more clearly the lateral anterior medullary veins. The *transverse pontine veins* are usually large in calibre and drain the venous network towards the basilar plexus and the superior petrosal vein.

II. Lateral Groups of Pontine Arteries and Veins

The lateral pontine surface consists of the middle cerebellar peduncle. It can be divided into three areas according to the position relative to the roots of the trigeminal nerve. These areas are different in appearance and each has its own vascular supply. These three areas are the *anterior*, between the roots of the trigeminal nerve and the limit of the anterior surface, the *inferior*, inferior to the trigeminal radicles and the *posterior*, between the trigeminal nerve and the posterior surface (Figs. 20–23).

a) Arteries and Veins of the Anterior Area of the Lateral Pontine Surface (Figs. 20–23, 54, 55, 57–59)

Arteries

This zone is supplied by the *lateral pontine arteries*, which are frequently mentioned in the literature (Stopford, 1916 a; Foix and Hillemand, 1925 a, 1925 c; Hassler, 1967; Gabrielsen and Amundsen, 1969; Stephens and Stilwell, 1969; Dor and Salamon, 1970). These observers describe numerous lateral pontine arteries, which was not found to be the case in this study. Two arteries usually occurred: the superior and inferior lateral pontine arteries. Occasionally, there were three or four. Sometimes, there is only one with superior and inferior branches. These lateral arteries arise from the basilar artery. In rare cases, the inferior lateral artery arises from the anterior inferior cerebellar artery (as has been noted by Stephens and Stilwell, 1969 and Foix and Hillemand, 1925 a, 1925 c).

The lateral pontine arteries (long lateral arteries, Gillilan, 1964) descend across the anterior surface of the pons towards the anterior area of the lateral surface, giving rise to few or no branches along their path. Ramifications occur suddenly in the anterior area of the lateral surface near the trigeminal nerve. The terminal branches often penetrate the pons in the grooves between the transverse corrugations at points where veins emerge.

The *superior lateral pontine artery* ramifies in the anterior area of the lateral surface above and in line with the roots of the trigeminal nerve. The *inferior lateral pontine artery* ramifies below the level of the trigeminal root. Some branches of the lateral pontine arteries penetrate the radicles of the trigeminal nerve, but no one branch is significantly large enough to be called the trigeminal artery, the name given by Duret (1873) and Watt and McKillop (1935). The superior and inferior lateral pontine arteries often anastomose, contrary to the observations of Kaplan and Ford (1966).

Veins

The veins of the anterior area of the lateral surface were observed to drain into the transverse pontine veins, which in turn drain into the superior petrosal vein. In some cases, branches of the transverse pontine veins form a venous circle around the roots of the trigeminal nerve.

b) Arteries and Veins of the Inferior Area of the Lateral Pontine Surface

(Figs. 18, 20, 22, 23, 54, 55, 57–59)

Arteries

This area is supplied by branches of the *anterior inferior cerebellar artery* (Atkinson, 1949; Stephens and Stilwell, 1969). In this zone, the anterior inferior cerebellar artery produces two sorts of branches:

1. Branches with a downward course, entering the pons in or just superior to the pontomedullary sulcus. These branches form the superior rami of the lateral medullary fossa (see p. 33).
2. Branches covering the middle cerebellar peduncle; one of these ramifies to form the posterior rami of the lateral medullary fossa after passing between the facial and vestibulocochlear nerves (see p. 33).

The other branches, with an upward course, mainly reach the roots of the trigeminal nerve in the neighbourhood of which they anastomose with branches of the inferior lateral pontine artery. Sometimes, some branches of the anterior inferior cerebellar artery pass behind the roots of the trigeminal nerve where they anastomose with branches of the superior lateral pontine artery, forming an arterial circle around the trigeminal roots, or sometimes around the sensory root only.

Branches of the anterior inferior cerebellar artery frequently enter the roots of the trigeminal nerve, which are thus vascularized not only by the lateral pontine branches of the basilar artery but also by the branches of the anterior inferior cerebellar artery, (see Fig. 30, section VII).

Veins
The veins of the inferior area of the lateral surface mainly drain into the anterior cerebellar vein. This vein is joined by the lateral pontine vein and drains into the superior petrosal vein after passing ventral or dorsal to the roots of the trigeminal nerve.

c) Arteries and Veins of the Posterior Area of the Lateral Surface (Figs. 21–23, 66)

Arteries
The branches of the superior cerebellar artery supplying this zone will be described in detail on p. 47. The inferior lateral branches of the superior cerebellar artery (Fig. 30, section VII) give rise to numerous branches which all have sinuous courses. The larger supply the deep regions of the cerebellum. Another artery in this area is the small posterolateral pontine artery, which is a branch of the terminal segment of the basilar artery (Figs. 20 and 54), and winds around the pons. It is often obscured by the branches of the superior cerebellar artery.

The superior lateral branches of the superior cerebellar artery (Fig. 31, section VIII) have characteristically straight horizontal courses and usually extend to the lower part of the lateral mesencephalic surface (Figs. 65 and 66). They belong to the lateral group of mesencephalic arteries (see p. 52).

Veins
The veins of the posterior area of the lateral surface drain into the inferior segment of the lateral mesencephalic vein, which traverses the posterior zone and enters the superior petrosal vein. In this zone, the vein of the superior cerebellar peduncle flows into the lateral mesencephalic vein (Figs. 21, 22, 23).

III. Posterior Groups of Pontine Arteries and Veins

The fourth ventricle occupies the inferior part of the posterior aspect of the pons; the superior part consists of the superior cerebellar peduncles (brachia conjunctiva), between which the superior medullary velum is situated (Fig. 3). The posterior surface is thus small in size. It is limited superiorly by the inferior colliculi between which the frenulum veli is situated. The trochlear nerves emerge from the posterior surface of the pons beneath the inferior colliculi.

a) Posterior Groups of Pontine Arteries (Figs. 17, 21, 22, 23)

The posterior group of arteries is derived from the superior cerebellar artery (see p. 52); it consists of a few slender branches which follow the superior cerebellar peduncles and penetrate them at various points (Fig. 30, section VII). Some of these, however, enter the pons in the infracollicular recesses near the trochlear nerve (Figs. 21 and 31, section VIII). Exceptionally, a small artery enters the recesses on each side of the frenulum veli.

b) Posterior Group of Pontine Veins (Figs. 19, 21, 22, 23, 61, 66)

The veins of the posterior group are much larger than the corresponding arteries. They emerge from the superior cerebellar peduncles and drain into the lateral mesencephalic veins and into the veins of the superior cerebellar peduncles (veins of the brachia conjunctiva), which will be described with the superficial veins of the mesencephalon on p. 47. This group also contains veins emerging from the infracollicular recesses and the recesses of the frenulum veli which are much larger than the corresponding arteries (Fig. 31, section VIII; Figs. 21, 31, 89, 92, 93).

B. Internal Territories of the Arteries and Veins of the Pons

The territories of the anterior, lateral and posterior groups will be studied in four levels of the pons (in caudal to cranial order: Fig. 28, section V, to Fig. 31, section VIII). This detailed description will be followed by a general account of the relationship between the vascular territories and by a summary of the veins and arteries of the main tracts and nuclei of the pons.

I. Internal Territories of the Anterior Groups of Pontine Arteries and Veins

a) Internal Territories of the Anteromedial Groups of Pontine Arteries and Veins (Figs. 28, 29, 30 and 31, sections V–VIII; Figs 128, 129, 138 and 143)

Internal Territory of the Anteromedial Group of Pontine Arteries

The anteromedial pontine arteries penetrate the pons at the edges of the basilar sulcus (medial perforators, Kaplan and Ford, 1966). As is the case in the medulla, there are two types of anteromedial arteries: the longer arteries which reach the floor of the ventricle where they supply the median zone of the pontine tegmentum, and the shorter arteries which go no further than the medial lemniscus, mainly supplying the medial zone of the corticospinal tract.

Only the longer arteries supplying intermediate levels of the pontine tegmentum are straight (Fig. 29, section VI). Those which vascularize the superior and inferior zones of the pontine tegmentum are usually curved (Fig. 28d).

The long anteromedial arteries which supply the inferior zone of the tegmentum (Fig. 28, section V) arise from superficial arteries of the foramen caecum (Fig. 27, section IV). They reach the tegmentum along a curved upward path and supply almost all the abducent nucleus, the medial longitudinal fasciculus and the caudal pontine reticular nucleus.

The long anteromedial arteries which supply the superior zone of the pontine tegmentum arise from the inferior pedicle of the interpeduncular fossa (Fig. 32, section IX) (see p. 51). They curve down in the tegmentum (Figs. 30 and 31, sections VII and VIII) to supply the medial longitudinal fasciculus and oral pontine reticular nucleus. Stephens and Stilwell (1969) consider that the characteristic route of these anteromedial arteries is due to the greater size of the ventral part of the pons in man.

Internal Territory of the Anteromedial Group of Pontine Veins

The anteromedial group of pontine veins follow paths very similar to those of the arteries; only the anteromedial veins draining the middle levels of the tegmentum have direct courses.

The anteromedial veins of the inferior tegmentum drain into the veins of the foramen caecum and those in the superior part, into the veins of the interpeduncular fossa. This arrangement is particularly characteristic of the upper pontine tegmentum, where the vessels of the interpeduncular fossa can be seen not only in Fig. 31, section VIII, but also in Fig. 30, section VII.

b) Internal Territories of the Anterolateral Groups of Pontine Arteries and Veins

(Figs. 28, 29,30 and 31, sections V–VIII; Figs. 129 and 138)

Both arteries and veins here are larger and more numerous than the corresponding medullary vessels.

Internal Territory of Anterolateral Group of Pontine Arteries

The anterolateral pontine arteries are numerous; some supply the anterior surface of the corticospinal tract (Bebin, 1968), but most curve round the corticospinal tract to supply its lateral region, and thus also supply the pontine nuclei and sometimes the medial lemniscus.

Internal Territories of Anterolateral Group of Pontine Veins

The anterolateral veins are very large and long. They drain a larger territory than is supplied by the arteries. This includes not only the corticospinal tract and the medial lemniscus but also part of the tegmentum. These principal anterolateral veins skirt the lateral aspect of the corticospinal tract, where they are joined by numerous transverse branches draining the separate fasciculi of the corticospinal tract and the neighbouring pontine nuclei.

II. Internal Territories of the Lateral Groups of Pontine Arteries and Veins

The internal courses of arteries and veins in the *anterior, inferior* and *posterior* areas of the lateral surface will be described, in that order.

a) Internal Territories of the Arteries and Veins of the Anterior Area of the Pontine Lateral Surface

Arteries

The numerous branches of the lateral pontine arteries (lateral perforators, Kaplan and Ford, 1966) supply the pontine nuclei. The longer of these reach intermediate levels of the tegmentum (Fig. 29, section VI). Here they form part of the vascular system of the lateral lemniscus and its nucleus (which is a continuation of the superior olive), part of the motor trigeminal nucleus and part of the central tegmental tract The more medial lateral pontine arteries supply (together with the anterolateral arteries) the lateral sides of the corticospinal tract. The more laterally situated branches of the lateral pontine arteries ramify on and penetrate the roots of the trigeminal nerve extending to the principal sensory and motor trigeminal nuclei (Fig. 29, section VI). The territory of the lateral pontine arteries does not extend to the upper part of the pons (Fig. 31, section VIII). Thus the lateral pontine arteries supply a relatively small area.

Veins

The territory drained by the internal lateral pontine veins is very similar to that supplied by the corresponding arteries. In rare exceptions, large principal lateral veins, mainly in the lower part of the pons, drain all the pontine tegmentum (Fig. 28, section V).

b) Internal Territories of the Arteries and Veins of the Inferior Area of the Pontine Lateral Surface

Arteries

The arteries in this zone arise from the anterior inferior cerebellar artery which, as already noted, has two kinds of branches (see p. 40).

The branches penetrating at the pontomedullary sulcus form the superior rami of the lateral medullary fossa. They have a central cranial course towards inferior levels of the pontine tegmentum (Fig. 28, section V) where they supply a clearly defined territory: the superior olivary nucleus, the facial nucleus, the lateral lemniscus and sometimes the lateral parts of the abducent nucleus and the central tegmental tract (Fig. 28, section V). The territory supplied by these branches seems to be that which is affected in the lateral inferior pontine syndrome (Aleksic and Budzilovich, 1973), which includes lesions of the facial nucleus and of auditory nuclei.

The branches covering the middle cerebellar peduncle constitute the arterial supply of this peduncle. Some of them penetrate the roots of the trigeminal nerve and, together with the lateral pontine arteries described above, run down the nerve to supply the principal sensory nucleus. Some even vascularize the superior vestibular nucleus (Fig. 29, section VI).

Veins

The veins draining the inferior area of the lateral aspect of the pons cover the same territory as the arteries.

c) Internal Territories of the Arteries and Veins of the Posterior Area of the Pontine Lateral Surface

These arteries and veins are limited to the superior part of the pons (Figs. 30 and 31, sections VII and VIII).

Arteries

The arteries in the posterior area are mainly rami of the superior cerebellar arteries and, to a lesser extent, of the posterolateral pontine artery which is a direct branch of the basilar artery (see p. 61).

After penetrating near the sulcus separating the lateral surface of the pons from the superior cerebellar peduncle, these small arteries supply the lateral part of the upper pontine tegmentum, i.e. the nucleus reticularis pontis oralis, the central tegmental tract, the lateral lemniscus and part of the superior cerebellar peduncle. Several terminal branches also supply the nucleus coeruleus. Most of the arteries found in the tegmentum at level VII (Fig. 30) penetrate at level VIII (Fig. 31) and hence descend, as do the majority of the arteries and veins of the upper tegmentum.

Veins

The veins of the posterior area of the lateral surface are few in number but large in calibre, and their territory is identical to that supplied by the arteries.

III. Internal Territories of the Posterior Groups of Pontine Arteries and Veins

a) Internal Territory of the Posterior Pontine Arteries (Figs. 30 and 31, sections VII and VIII)

These arteries branch from the medial superior cerebellar arteries. They penetrate the superior cerebellar peduncle. They supply the peduncle, the mesencephalic trigeminal tract and the locus coeruleus (Amarenco and Hauw, 1989). These arteries enter at different points along the side of the superior peduncle and are all small in diameter. Some have different courses and penetrate at the infracollicular recess and the recess of the frenulum veli (Fig. 31, section VIII; Fig. 136). It is relatively rare for arteries to penetrate the recess of the frenulum veli. The artery penetrating the infracollicular recess is sometimes large and vascularizes the superior pole of the locus coeruleus.

b) Internal Territory of the Posterior Group of Pontine Veins

Unlike the arteries, these veins are large in size. There are usually three or four internal posterior veins emerging from the surface of the superior cerebellar peduncle at different points. They usually traverse the nucleus coeruleus (veins of the nucleus coeruleus). The most inferior vein penetrates the nucleus coeruleus, and ascends through it for some way before leaving the nucleus coeruleus and reaching the surface of superior cerebellar peduncle (Fig. 30, section VII).

The territory drained by the posterior veins extends much further than that of the corresponding arteries and comprises not only the nucleus coeruleus but also most of the upper part of the tegmentum.

The most inferior vein (inferior vein of the nucleus coeruleus), usually the largest, emerges at level VII (Fig. 30) and drains a territory below this (level VI) (Fig. 29) through long subependymal branches (Fig. 21). The veins higher up emerge from the infracollicular recess and from the recess of frenulum veli.

The small vein emerging from the latter recess (inferior central collicular vein, see p. 55) comes from a higher level and is described with the veins of the mesencephalon. The vein of the infracollicular recess is often large, draining the superior pole of the nucleus coeruleus (superior vein of the nucleus coeruleus).

In two brain stems, an anastomosis linking this vein with an anterolateral vein belonging to level IX (Fig. 32) was observed. This anastomosis traversed the upper part of the brain stem.

IV. Subependymal Pontine Veins of the Floor of the Fourth Ventricle

Like the veins of the medulla, the principal pontine veins ramify under the ventricular ependyma. A notable feature is the arrangement of the large inferior veins of the nucleus coeruleus, the subependymal branches of which can be divided into lateral and medial rami (Fig. 21; Fig. 29 and 30, sections VI and VII). The lateral rami extend across the vestibular area, and the medial rami are adjacent to the median sulcus of the floor of the fourth ventricle. These subependymal veins can often be identified at inferior levels (Fig. 29 and30, sections VI and VII)

V. General Survey of the Internal Territories of the Pons

a) Arterial Territories

The arteries of the anterior group (anteromedial and anterolateral pontine arteries) supply a large territory comprising mainly the corticospinal tract and the pontine nuclei. They vascularize most of the abducent nucleus, the medial longitudinal fasciculus, the medial part of the central tegmental tract and the neighbouring reticular substance. They also supply part of the medial lemniscus.

The arteries of the lateral group, divided into arteries of the anterior, inferior and posterior areas of the lateral surface, supply the lateral margin of the corticospinal tract and the surrounding pontine nuclei, the lateral region of the pontine tegmentum, comprising in ascending order: the facial and superior olivary nuclei, the lateral part of the abducent nucleus, the trigeminal nuclei and part of the locus coeruleus. Arteries of this group also supply the lateral lemniscus and parts of the medial lemniscus, central tegmental tract and superior cerebellar peduncle.

The arteries of the posterior group occur only at superior pontine levels. They vascularize a small region confined to the superior cerebellar peduncle, nucleus coeruleus and the mesencephalic trigeminal tract.

b) Venous Territories

The pontine veins in general drain territories similar to those of the corresponding arteries. However, it is to be noted that, as in the medulla, large principal veins sometimes occur in the anterolateral, lateral and posterior groups (veins of the nucleus coeruleus). The veins then drain territories much larger than those supplied by the corresponding arteries.

One feature of the pontine vascularization by the basilar artery is especially notable (see Figs. 28a and 143): the pontine branches of the basilar artery (anteromedial, anterolateral and lateral) mainly supply the ventral part of the pons and play only a very small role in the vascularization of the tegmentum.

The tegmentum is supplied medially by arteries from the basilar artery above the level of the pons (inferior pedicle of the interpeduncular fossa) and by branches of the same artery inferior to the pons (arteries of the foramen caecum). The lateral regions of the tegmentum are mainly supplied by the anterior inferior and superior cerebellar arteries. Thus, the pontine segment of the basilar artery contributes very little to the vascularization of the pontine tegmentum, which may explain how the tegmentum remains intact after lesions of the pontine segment of the basilar artery (Biemond, 1951).

VI. Vascularization of Tracts and Nuclei in the Pons

a) Tracts

The corticospinal tract is mainly vascularized by the anterior groups of arteries and veins; those of the lateral group sometimes assist in the vascularization of this tract (Figs. 30 and 31, sections VII and VIII).

The lemnisci are supplied by arteries from several different groups: the medial is supplied by the anterior group, whereas the lateral is supplied, in ascending order, by branches from the anterior inferior cerebellar artery (Fig. 28, section V), the lateral pontine arteries (Fig. 29, section VI) and the superior cerebellar arteries (Figs. 30 and 31, sections VII and VIII).

b) Nuclei

The abducent nucleus is mainly supplied by the arteries of the foramen caecum. The lateral pontine arteries and the superior rami of the lateral medullary fossa (Fig. 28, section V) vascularize an extremely small part of this nucleus, whereas the lateral pontine veins drain most of the nucleus.

The principal sensory and the motor trigeminal nuclei are supplied mainly by the lateral pontine arteries (motor nucleus) and by the anterior inferior cerebellar artery (principal sensory nucleus) (Fig. 29, section VI). No single artery can be named the trigeminal; many branches of the arteries mentioned above enter the roots of the nerve and thus penetrate to its nuclei (GILLILAN, 1964).

The nucleus coeruleus is supplied by many small rami of the superior cerebellar arteries (Figs. 30 and 31, sections VII and VIII). Numerous large veins traverse the nucleus coeruleus and emerge on the surface of the superior cerebellar peduncle (see p. 43).

It is to be noted that the facial and superior olivary nuclei are vascularized by veins and arteries belonging almost exclusively to the superior rami of the lateral medullary fossa (Fig. 28, section V).

Mesencephalon

As in the medulla and the pons, it is convenient in studies of the vascular supply to divide the mesencephalon into anterior, lateral, and posterior surfaces (see Figs. 2, 3 and 4) supplied by anterior (anteromedial and anterolateral), lateral, and posterior groups of mesencephalic vessels.

A. Superficial Arteries and Veins of the Mesencephalon

(Figs. 16–23, 32, section IX; Figs. 32 and 33, section X)

The arrangement of the blood vessels in relation to the mesencephalon are so dense and complex that the anatomy of the mesencephalic arteries and veins, as well as of their anterior, lateral and posterior branches, will be first described before presenting the general constitution of the anterior, lateral and posterior groups of mesencephalic vessels and their internal territories.

I. Arteries in Relation to the Mesencephalon

The arteries in relation to the mesencephalon curve round the mesencephalon: the superior cerebellar, collicular, medial posterior choroidal, posterior cerebral and anterior choroidal arteries, from lower to upper level. These arteries, and their mesencephalic branches, have received little attention. The most important descriptions are the little-known and relatively inaccessible works of ALEZAIS et D'ASTROS (1892 a, 1892 b) and KHAN (1969), the conclusions of which are, in many details, in agreement with those described here.

a) **Basilar Artery** (Figs. 16, 20, 50–55)

The basilar artery is only slightly involved in the vascularization of mesencephalon; its terminal segment gives rise to anteromedial branches reaching the pontine tegmentum (see p. 70) but ALEZAIS et D'ASTROS (1892 a) describe some branches of the basilar artery which reach the pontomesencephalic sulcus and supply the crus cerebri.

b) **Superior Cerebellar Artery** (Figs. 16, 20–23)

The superior cerebellar artery branches from the basilar artery on the anterior surface of the pons just below the pontomesencephalic sulcus (Fig. 54). Its first segment crosses the anterior surface of the pons and reaches the pontomesencephalic sulcus (anterior pontine segment. HOFFMAN et al. 1974) (Fig. 63). The division into two branches (lateral and medial, Figs. 54 and 65) usually occurs in this segment. The lateral superior cerebellar artery curves sharply to reach the lateral margin of the cerebellar hemisphere. The medial superior cerebellar artery runs in the same direction, as the continuation of the stem of the cerebellar artery, curving round the lateral surface of the mesencephalon (Hoffman's 'ambient segment') to reach the colliculi (Hoffman's quadrigeminal segment). In the collicular region, the medial superior cerebellar artery usually loops upwards along the superior border of the inferior colliculus (Fig. 64). In rare cases, the artery loops more caudally along the inferior border of the colliculus.

The medial superior cerebellar artery reaches the longitudinal intercollicular sulcus, runs alongside the precentral vein and reaches the superior vermis. As numerous authors have shown (KAPLAN and FORD 1966; KRAYENBUHL and YASARGIL 1968; KHAN 1969; HOFFMAN et al. 1974), the course and mode of division of the superior cerebellar arteries frequently vary. The medial and lateral superior cerebellar arteries sometimes arise separately from the basilar artery. Sometimes they are multiple. The following description is based on the most frequent arrangement, comprising the lateral and medial superior cerebellar arteries, the anterior, lateral and posterior branches of which will now be described.

Anterior Branches
Anteromedial branches are rare. KHAN (1969) notes the possible occurrence of small branches reaching the interpeduncular fossa and becoming part of the lateral rami of the intermediate pedicle.

Anterolateral branches are also rare, but in this study some arteries arising from the cerebellar artery and reaching the pontomesencephalic sulcus were observed (Fig. 31, section VIII).

Lateral Branches (Figs. 22 and 23; Figs. 30 and 31, section VII and VIII)
The lateral branches of the superior cerebellar artery may be described as two groups of rami, inferior and superior (Fig. 66), which are in fact poorly involved in the vascularization of the mesencephalon.

The inferior lateral rami arise mainly from the lateral superior cerebellar artery. They follow sinuous courses along the posterior area of the lateral surface of the pons (Fig. 30, section VII). Some of these arteries reach the sulcus between the lateral surface of the pons and the superior cerebellar peduncle and supply the pontine tegmentum (see p. 43) (Fig. 30, section VII). Other more numerous arteries enter the cerebellum along its superior peduncle and supply the dentate nucleus (STEPHENS and STILWELL 1969).

The superior lateral rami arise from both the medial and the lateral superior cerebellar arteries; these rami display a straight horizontal course before entering the midbrain in the lateral mesencephalic sulcus on each side of the lateral mesencephalic vein (Fig. 31, section VIII). These arteries supply the pontine tegmentum. They are described in the chapter on the arteries and veins of the pons (see p. 41).

Posterior Branches (Figs. 21–23)
The posterior branches of the superior cerebellar artery reach the posterior surfaces of the pons and the mesencephalon.

The branches to the posterior surface of the pons vascularize the superior cerebellar peduncle. Arising from the medial superior cerebellar artery. they follow the superior cerebellar peduncle before entering at multiple loci (see p. 43).

The branches to the posterior surface of the mesencephalon supply the inferior colliculus; they all branch from the medial superior cerebellar artery and form a dense arterial network, covering the superior part of the inferior colliculus and the transverse intercollicular sulcus. Here, the branches of the superior cerebellar artery display numerous anastomoses with the terminal branches of the collicular artery (Figs. 88–91), as ALEZAIS et D'ASTROS (1892 a) have shown.

The surface served by the posterior branches of the superior cerebellar artery which supplies the colliculi varies greatly in size. Sometimes, these posterior branches ramify over both the superior part of the inferior colliculus and the inferior part of the superior colliculus normally served by the collicular artery (Fig. 21). Branches of the superior cerebellar artery supplying the pineal body were never observed, contrary to the observations of many workers; the observations in this study thus confirm those made by KHAN (1969). In conclusion, these observations indicate that the branches of the superior cerebellar artery supplying the mesencephalon are few on the anterior surface, more numerous on the lateral surface and very numerous on the posterior surface of the mesencephalon.

c) **Collicular Artery** (Figs. 21–23)

The terminology of this vessel is extremely variable; many authorities follow FOIX and HILLEMAND (1925 b, c), using the term „quadrigeminal artery". This study follows KHAN (1969) in using the term „collicular artery", which corresponds more closely to international terminology. The term „pedunculo-quadrigeminal artery" used by ALEZAIS et D'ASTROS (1892 a), would in fact be more precise, because this vessel supplies both the colliculi and the cerebral peduncle.

The collicular artery leaves the posterior cerebral artery near the side of the interpeduncular fossa. Here the collicular artery is always close to the oculomotor radicles (MILISAVLJEVIC et al. 1986); it is sometimes superior, sometimes inferior and sometimes transverse to the nerve. In agreement with KHAN (1969), the artery was most frequently observed to be superior to the nerve.

The artery first traverses the anterior surface of the crus cerebri, frequently closely following the pontomesencephalic sulcus. When it reaches the lateral margin of the crus cerebri, the collicular artery ascends across its lateral side and reaches the lateral mesencephalic sulcus (Figs. 65 and 66). Its course is remarkably straight up to this point, but it now inclines sharply upwards and reaches the brachium of the inferior colliculus by a sinuous route. Here it divides into two terminal branches which progressively diverge. The inferior branch reaches the transverse intercollicular sulcus; the superior divides into numerous small rami on the surface of the superior colliculi (Figs. 21, 89, 90, 91). In rare cases, the collicular artery reaches the colliculi without branching (Fig. 88).

In all brain stems studied, an accessory collicular artery (Figs. 22, 23), branching from the initial segment of the main collicular artery and following it closely on its upper side as far as the lateral mesencephalic sulcus, was noted. Ascending, it crosses the inferior and superior collicular brachia, where it is hidden by the medial posterior choroidal arteries. Its terminal branches usually supply the lateral segment of the superior colliculus. However, the accessory collicular artery frequently extends no further than the superior collicular brachium, and it even sometimes ends into the lateral mesencephalic sulcus. Numerous authors have described the existence of an accessory collicular artery (Foix and Hillemand 1925 b; Namin 1955; Khan 1969; Wackenheim and Braun 1970; Lazorthes et al. 1976). The main and accessory collicular arteries have many branches which are here grouped as anterior, lateral and posterior.

Anterior Branches

Anteromedial Branches. These were rarely observed contrary to Khan's (1969) description. Sometimes the branches of the collicular arteries form part of the lateral rami of the intermediate pedicle of the interpeduncular fossa (Fig. 20, Figs. 32 and 33, sections IX and X).

Anterolateral Branches. These branches are numerous, arising from both the principal and accessory collicular arteries. Their superficial course is short, penetrating the grooves of the corrugated surface of the crus cerebri where they are often accompanied by a small satellite vein (Fig. 20, Figs. 32 and 33, sections IX and X). These branches only occur on the lower part of the crus cerebri near the pontomesencephalic sulcus.

Lateral Branches

These are branches of both the principal and accessory collicular arteries near the lateral margin of the crus cerebri; they follow the main arterial trunk along a straight route until they reach the middle segment of the lateral mesencephalic sulcus (Figs. 21–23, 66). Some go even further and penetrate the lateral surface of the mesencephalon. Just before they penetrate nervous tissue, these branches frequently anastomose with branches of the medial posterior choroidal artery above, or more rarely with, the branches of the superior cerebellar artery below. These lateral anastomoses are not always present.

The accessory collicular artery sometimes forms a network of anastomotic links with branches of the posteromedial choroidal artery on the surface of the superior collicular brachium (Fig. 22).

Posterior Branches

These posterior branches are derived from the terminal branches of the principal collicular artery. On the surface of the superior colliculus they form a particularly dense arterial network which hides the subjacent superficial veins (Figs. 21, 88–91).

The inferior terminal branch ramifies in the transverse intercollicular sulcus where its rami anastomose frequently with the branches of the superior cerebellar artery.

The superior terminal branch is often larger; it ramifies on the surface of the superior colliculus, forming its main arterial supply inferiorly, the upper part being supplied by branches of the medial posterior choroidal artery with which the branches of the collicular artery anastomose frequently. It is to be noted that there is little or no vascularization of the vertical intercollicular sulcus, which thus forms a clear demarcation line between the left and right arterial networks (Figs. 89 and 90).

The area supplied by the posterior branches of the collicular artery varies greatly in size, the function of these branches being taken over by those of the superior cerebellar artery and by the branches of the medial posterior choroidal artery.

It is therefore concluded, in agreement with Khan (1969), that all the branches of the collicular artery supply the mesencephalon, those serving the colliculi being more or less numerous according to the subject.

d) Medial Posterior Choroidal Artery (Figs. 20–23)

The medial posterior choroidal artery has been described by numerous workers, particularly by Duret (1874), Galloway and Greitz (1960), Yamamoto and Kageyama (1980), and Vinas et al. (1995). Their terminology is preferred here, and differs from that used by Abbie (1933 a) and Khan (1969). The usual path of the medial posterior choroidal artery and then the numerous variations will be described.

The medial posterior choroidal artery arises from the posterior cerebral artery on the anterior surface of the crus cerebri, above the commencement of the collicular artery, usually in the neighbourhood of the interpeduncular fossa, but sometimes more laterally.

The medial posterior choroidal artery then curves around the crus cerebri above the collicular artery obscuring its anterolateral branches (Figs. 65 and 66). When it reaches the lateral margin of the mesencephalon, the medial posterior choroidal artery inclines upwards to reach the upper part of the lateral mesencephalic sulcus inferior to the medial geniculate body; it follows the inferior border of the geniculate body and, when it reaches its posterior margin, it continues sinuously, being partly hidden by the pulvinar. It hides the branches of the accessory collicular artery which cover the surface of the superior collicular brachium (Figs. 22 and 23). The medial posterior choroidal artery then reaches the posterior surface of the mesencephalon, where its meanderings are more numerous and pronounced, but its general direction remains along the edge of the pulvinar. Here its numerous branches cover the pretectal area between the pulvinar, habenula and pineal gland (Figs. 81, 88– 90). This segment of the medial posterior choroidal artery adjoins the pineal gland, usually on its lateral side (GALLOWAY and GREITZ 1960) (Figs. 89 and 90) but sometimes curving over the gland (LÖFGREN 1958) (Fig. 81). However, the special relationship between this artery and the gland is subject to considerable variation, and it seems impossible to define a particular relation between the two. Having crossed the pretectal area, the posteromedial choroidal artery enters the tela choroidea of the third ventricle, thus leaving the mesencephalon.

Variations
The relatively simple course described above is considered by GALLOWAY and GREITZ (1960) to be the usual rule (arteria choroidea posteromedialis oralis, SCHLESINGER 1976). It is in fact very rarely found as such. More often than not, the medial posterior choroidal artery consists of two or even three trunks, making the study of this artery particularly difficult (Figs. 22 and 64).(This doubtless explains the lack of clarity in some descriptions.) These trunks arise from the posterior cerebral artery near the medial geniculate body where this artery leaves the lateral margin of the mesencephalon on its way towards the temporo-occipital lobe (arteria choroidea posteromedialis caudalis, SCHLESINGER 1976). These trunks may also arise either from the thalamogeniculate arteries or from the temporal and occipital branches of the posterior cerebral artery (Fig. 64). All the arteries which form the medial posterior complex usually show frequent anastomoses; not all of them reach the tela choroidea of the third ventricle but here they are included in this group even if they go no further than the posterior surface of the mesencephalon and the pretectal area.

The proximal segment of the 'typical' medial posterior choroidal artery adjacent to the crus cerebri is sometimes completely missing, or sometimes present as a small vessel which can then be named the accessory medial posterior choroidal artery (Figs. 20 and 22).

The different trunks of the medial posterior choroidal artery have many branches which will be grouped as anterior, lateral and posterior.

Anterior Branches
The anterior branches are not consistently present, like the proximal segment of the medial posterior choroidal artery.

Anteromedial Branches. Like the anteromedial branches of the collicular artery, those of the medial posterior choroidal artery, when present, make up part of the lateral rami of the intermediate pedicle of the interpeduncular fossa (see p. 51).

Anterolateral Branches. The anterolateral branches are sometimes numerous. They cross the anterior surface of the crus cerebri above the anterolateral branches of the collicular artery, with which they sometimes anastomose. Like the anterolateral branches of the collicular artery, they cover only the lower part of the surface of the crus cerebri (Fig. 20).

Lateral Branches
Numerous small arteries enter the medial geniculate body inferiorly and the superior part of the lateral mesencephalic sulcus, where they frequently anastomose with branches of the collicular artery. Some of them penetrate the surface of the medial geniculate body (Figs. 23, 65).

Posterior Branches
Branches Not Serving the Mesencephalic Region. The posterior branches of the medial posterior choroidal artery are more numerous and larger than those of its anterior and lateral groups. When the posterior cerebral artery leaves the mesencephalon near the medial geniculate body, the medial posterior choroidal arteries take over its function and numerous branches arise from them and run towards the thalamus, becoming part of the thalamogeniculate group of arteries (Fig. 65). These posterior branches enter the midbrain at the deep sulcus between the medial geniculate body and the pretectal region on the one hand, and the pulvinar on the other. As well as these branches, which supply the thalamus (arteria pulvinaris inferior, SCHLESINGER 1976) others arise from the medial posterior choroidal artery to

supply the pineal body at its lateral aspect (pineal arteries, see Figs. 81, 82, 85 and 91) (Le Gros Clark 1940; Galloway and Greitz 1960), the habenular trigone and the pretectal region.

Branches to the Posterior Surface of the Mesencephalon. The number of these branches varies considerably from one subject to another. In most, these branches are part of the dense arterial network described above on the surface of the colliculi (Figs. 21, 88, 89, 90). Usually, the branches of the medial posterior choroidal artery supply only the part of the superior colliculus near the pineal body but where the collicular artery is particularly small, the branches of the posterior medial choroidal arteries serve the whole surface of the superior colliculus.

e) Posterior Cerebral Artery

The initial segment of the posterior cerebral artery supplies the mesencephalon. The posterior cerebral arteries are usually the terminal branches of the basilar artery (Fig. 34), but sometimes the posterior cerebral artery is derived from the internal carotid artery; a short artery of small diameter then joins the basilar artery to the posterior cerebral artery. Variations in this initial segment and their significance will not be described here. The reader is referred to the considerable literature on this subject, notably to Krayenbühl and Yasargil (1957) and Hoyt et al. (1974).

The mesencephalic segment of the posterior cerebral artery crosses the anterior surface of the crus cerebri (Figs. 62–64) where it overlies the collicular arteries and the posteromedial choroidal artery. It ascends to the lateral margin of the mesencephalon, where it curves round the mesencephalon. Level with the medial geniculate body, it abruptly leaves the region in the direction of the temporo-occipital lobe (Fig. 64) The mesencephalic segment of the posterior cerebral artery gives rise to numerous branches:

1. The long branches are the lateral posterior choroidal artery, which supplies the choroid plexus of the inferior horn of the lateral ventricle (Fig. 64), and the collicular and medial posterior choroidal arteries already described.
2. The short branches can be divided into anterior and lateral groups arranged as follows.

Anterior Branches

Anteromedial Branches (Fig. 20). These are very numerous rami which form the majority of the arteries in the interpeduncular fossa. The anteromedial branches of the posterior cerebral artery form the superior arterial pedicle of the interpeduncular fossa. They also constitute most of the intermediate pedicle to which a few branches from the collicular or medial posterior choroidal arteries also sometimes contribute (see p. 51).

Anterolateral Branches (Fig. 20). As Khan (1969) has reported, the number of these branches varies considerably. They are usually small and few in number, and they enter the crus cerebri above the branches of the collicular and medial posterior choroidal arteries, usually adjoining the medial and lateral margins of the crus cerebri, as has been noted by Stephens and Stilwell (1969).

Lateral Branches

Few lateral branches, and usually none of the posterior cerebral artery, supply the mesencephalon, almost always supplying the thalamus (thalamogeniculate arteries) (Figs. 64 and 65). These branches arise from the posterior cerebral artery near the medial and lateral geniculate bodies. They penetrate the mesencephalon in the thalamogeniculate sulcus. Some branches anastomose with branches of the anterior choroidal artery on the surface of the lateral geniculate body. Because the posterior cerebral artery leaves the lateral surface of the mesencephalon, there are no posterior branches. As already stated (see p. 49), here the posterior medial choroidal arteries take over on the posterior surface of the mesencephalon, where their branches are part of the thalamogeniculate arteries.

f) Anterior Choroidal Artery

The anterior choroidal artery arises from the internal carotid artery, and supplies the optic tract and then the choroid plexus of the inferior horn, as does the lateral posterior choroidal artery (Abbie 1933 b) (Figs. 20 and 62, 63). Numerous branches arise from the anterior choroidal artery, penetrating the optic tract and eventually supplying deeper regions of the brain. One branch consistently reaches the temporal lobe, where it supplies the uncus (uncal branch) (Duvernoy 1998).

The mesencephalic branches are not numerous; some small inconstant arteries supply the superior levels in the crus cerebri where they anastomose with branches from the collicular and medial posterior choroidal arteries at its inferior margin (Fig. 20). These observations confirm those of Khan (1969). Abbie (1933 b), on the other hand, gives greater importance to the anterior choroidal artery which, in his opinion, supplies much of the crus cerebri.

In conclusion, it can be stated that the different arteries studied have complementary roles in the vascularization of the mesencephalon. Their almost parallel courses crossing the interpeduncular, crural, and ambient cisterns incline upward and serve territories arranged as ascending bands. In the lowest band, the superior cerebellar artery has few branches in the anterior part, more in the lateral part and most in the posterior part of the mesencephalon; in the highest band, the posterior cerebral artery has most branches in the anterior part, a few in the lateral part and none in the posterior part of the mesencephalon. The two intermediary bands are supplied by the collicular and posteromedial choroidal arteries, mainly in the lateral and posterior regions. The arrangement can be seen in an illustration in KHAN (1969) and in Figs. 17, 22, 23 and 32b.

II. Veins in Relation to the Mesencephalon

Details of the superficial veins of the mesencephalon can be found in HUANG and WOLF (1965), KHAN (1969), DUVERNOY (1975) and MATSUSHIMA et al. (1983). The general arrangement of the larger veins will be described here (see Figs. 18, 19, 67–74, 92 and 93 for more details).

The main venous trunk is the basal vein. The basal vein arises in the anterior perforated substance by the junction of anterior cerebral, deep middle cerebral and inferior striate veins (Figs. 67 and 68). The path of the basal vein is divided into a ventral and a laterodorsal segment.

On the ventral surface of the mesencephalon, the ventral segment of the basal vein (Figs. 62, 68–72) crosses the superior part of the crus cerebri. It is joined by the vein of the inferior horn and the interpeduncular vein. The left and right interpeduncular veins are linked by the posterior communicating vein and have frequent anastomoses with the median anterior pontine vein. At inferior level of the crus cerebri, the vein of the pontomesencephalic sulcus is sometimes large (Fig. 20).

On the lateral surface of the mesencephalon, the dorsolateral segment of the basal vein is the most important venous trunk (Figs. 19, 23, 65, 73, 74). It is joined to the superior petrosal vein by the lateral mesencephalic vein which runs along the lateral mesencephalic sulcus.

On the posterior surface of the mesencephalon the terminal segment of the basal vein usually drains into the great cerebral vein (of Galen) (Figs. 73, 77, 80). However, the terminal segment of the basal vein sometimes drains into the superior petrosal vein, the small accessory basal vein (posterior mesencephalic vein) linking the basal vein to the great cerebral vein in such instances (Fig. 22). In the lower part of the posterior surface of the mesencephalon, the precentral vein follows the median line and drains into the great cerebral vein (Figs. 92 and 93). This precentral vein (Khan's dorsal mesencephalic vein) is formed by the junction, in the median line, of the left and right veins of the superior cerebellar peduncle (vein of the brachium conjunctivum, HUANG and WOLF 1965), (Fig. 61). The lower segment of these veins anastomoses with the lateral mesencephalic veins (Figs. 19 and 21). Many small veins drain the dorsal surface of the mesencephalon into the large trunks described above. The veins of the collicular region have a cross-like aspect: superior and inferior median collicular veins (vertically oriented), and right and left intercollicular veins (horizontally oriented). The veins of the pineal gland and the collicular veins may be seen in Figs. 19, 21, 80–85, 87–89, 92 and 93.

III. Recapitulation of the Vascular Groups of Superficial Arteries and Veins of the Mesencephalon

a) Anterior Groups of Mesencephalic Arteries and Veins

Arteries

Anteromedial Group of Mesencephalic Arteries. The anteromedial group of mesencephalic arteries belongs to the arteries of the interpeduncular fossa which are frequently divided into three pedicles: superior (thalamoperforating arteries) supplying the thalamus, inferior arising from the terminal segment of the basilar artery and supplying the pontine tegmentum (see p. 70), and intermediate which constitute the anteromedial group of the mesencephalic arteries. According to its internal distribution (see below) this anteromedial group may be subdivided into a median group of rami which enter the mesencephalon in the median sulcus of the floor of the interpeduncular fossa, and two left and right lateral groups of rami, which penetrate the mesencephalon in the medial mesencephalic sulcus at the lateral border of the interpeduncular fossa and through the roots of the oculomotor nerve. The anteromedial group mainly arises from the posterior cerebral artery and sometimes from the collicular and medial posterior choroidal arteries (for more information about the arteries of the interpeduncular fossa, see MARINKOVIC et al. 1986; PEDROZA et al. 1986; SAEKI and RHOTON 1977).

Anterolateral Group of Mesencephalic Arteries. These small arteries penetrate between the corrugations of the surface of the crus cerebri. The superficial arterial network is mainly confined to the lower part of the crus in the neighbourhood of the pontomesencephalic sulcus, and few if any arteries supply the upper part. The anterolateral arteries are branches of the collicular, medial posterior choroidal and sometimes anterior choroidal and posterior cerebral arteries (Fig. 20). There are some anastomoses between the constituent vessels of this arterial network.

Veins

Anteromedial Groups of Mesencephalic Veins. The veins belonging to the anteromedial group drain into the interpeduncular veins and into the posterior communicating vein.

Anterolateral Group of Mesencephalic Veins. The veins of the anterolateral group emerge from the mesencephalon and often accompany the corresponding arteries. They are tributaries of the basal vein and the interpeduncular vein (Fig. 20).

b) Lateral Groups of Mesencephalic Arteries and Veins

The lateral group of arteries and veins is situated on the lateral surface of the mesencephalon (lemniscal trigone) and on the surface of the superior and inferior collicular brachia.

The lateral group of mesencephalic arteries can be divided into (a) arteries of the lateral mesencephalic sulcus and (b) arteries of the brachia.

The arteries of the lateral mesencephalic sulcus arise, in ascending order, from the superior cerebellar, collicular and posterior medial choroidal arteries at points which have already been described in detail. It will be remembered that, in most cases, they arise from the main arteries on the lateral margin of the crus cerebri, i.e. at some distance from the lateral sulcus. Their course to the sulcus is a straight one (Fig. 23). In other cases, they arise near the lateral sulcus and reach it by a short, sinuous course. In both cases, frequent anastomoses link the branches of superior cerebellar, collicular and posteromedial choroidal arteries (Alezais et D'Astros, 1892 a; Foix and Hillemand 1925 b; Khan 1969). The arteries of the lateral sulcus are small in size but very numerous and make up a clearly defined vascular hilum.

Arteries of the Superior and Inferior Collicular Brachia (Figs. 21–23). The inferior collicular brachium is vascularized by the superior cerebellar and collicular arteries. The branches of these arteries frequently anastomose.

The superior collicular brachium is covered by the dense arterial network formed by the terminal branches of the accessory collicular artery which frequently anastomose with the branches of the posterior medial choroidal artery (Fig. 22).

The adjacent geniculate bodies are covered by an arterial network arising from two different sources. The posterior part of the medial geniculate body is supplied by the posterior medial choroidal artery and the anterior part by the posterior cerebral artery (Figs. 22 and 23). The posterior part of the lateral geniculate body is supplied by the posterior cerebral artery and the anterior part by the anterior choroidal artery, (Abbie 1933 a) (Fig. 64).

The lateral group of mesencephalic veins emerging from the lateral mesencephalic sulcus mainly flow into the lateral mesencephalic and basal veins.

c) Posterior Group of Mesencephalic Arteries and Veins (Figs. 17, 19, 21, 88–93)

The arteries and veins covering the posterior mesencephalic surface are situated in two distinct regions: the arteries and veins in the pineal region are described in Figs. 75–86. The arteries and veins in the subjacent collicular region, in close relationship with the posterior mesencephalic aspect, give rise to the posterior groups of superficial mesencephalic arteries and veins which will now be described.

The posterior group of mesencephalic arteries form a dense network covering the colliculi (Fig. 34). Duret (1874) noted the exceptional density of this network, as did Foix and Hillemand (1925 b). The dissection of this network is made difficult by numerous arachnoid trabeculae, which link the small arteries together. The arterial network of the inferior and superior colliculi are composed of branches of different arteries, the relative importance of which is very variable from one brain to another and even from one side to another within the same brain:

The arterial network of the inferior colliculus has as its main source the superior cerebellar artery, sometimes assisted by the collicular artery (Figs. 21, 88–91). This arterial network is arranged mainly round the edges of the colliculus; the upper part, near the transverse intercollicular sulcus, is by far the most densely vascularized region and forms a pedicle filling the transverse intercollicular sulcus.

No superficial arteries are found on the lower part (Figs. 88 and 91), with the exception of a few small arteries which reach the infracollicular recess and the recess of the frenulum veli (see p. 43).

The arterial network of the superior colliculus: the superior colliculus is obscured, or covered, by numerous small arteries generally arising from the terminal branches of the collicular artery (Figs. 21, 88–91). The superior margin of the colliculus is often served by the posteromedial choroidal artery. Sometimes when the collicular artery is small, the superior cerebellar artery vascularizes the inferior zone of the colliculus.

The different branches forming the collicular right arterial networks have numerous anastomoses on each side but there are only a few anastomoses between the left and right networks, which seem to be separated by an avascular zone along the vertical intercollicular sulcus (Figs. 21, 89, 90).

The posterior groups of mesencephalic veins flow into the superficial veins of the colliculi which are hidden by the dense arterial network. They mainly occur at the peripheries of the colliculi and form the superior and inferior median collicular veins in the vertical intercollicular sulcus, and the left and right intercollicular veins in the transverse intercollicular sulci (Figs. 19, 21, 92, 93).

B. Internal Territories of the Arteries and Veins of the Mesencephalon

The territories of the anterior, lateral and posterior groups will be studied at two levels of the mesencephalon (Figs. 32 and 33, sections IX and X). This detailed description will be followed by a general account of the relationship between these vascular territories, and by a summary of the veins and arteries of the main tracts and nuclei of the mesencephalon.

I. Internal Territories of the Anterior Groups of Mesencephalic Arteries and Veins (Arteries and Veins of the Interpeduncular Fossa)

a) Internal Territory of the Anteromedial Group of Mesencephalic Arteries

The anteromedial group supplying the mesencephalon (KHAN's central arteries) includes only the intermediate pedicle of the interpeduncular fossa subdivided into lateral and median rami (see p. 51).

The median rami of the intermediate pedicle of the interpeduncular fossa enter the median sulcus of the interpeduncular fossa (Fig. 146). The longer and larger arteries (long central rami of KHAN) have no important collateral branches and follow a straight course on each side of the median line to the trochlear (Fig. 32, section IX) and oculomotor nuclei (Fig. 33, section X). It is to be noted that the terminal branches of these arteries often extend beyond the nuclei mentioned above and supply the periaqueductal grey matter and also sometimes the deep region of the superior colliculus (Fig. 33, section X).

The shorter, smaller arteries (short central rami of KHAN) are situated laterally and run parallel to the larger arteries. Their course in the mesencephalon is shorter, and they supply the medial part of the red nucleus (Fig. 33, section X).

The lateral rami of the intermediate pedicle of the interpeduncular fossa are composed of numerous but small arteries. They penetrate the mesencephalon, where the oculomotor nerve emerges or above the level of the oculomotor nerve in the medial mesencephalic sulcus. As soon as these arteries enter, they curve first towards the median line and then away from it, as do the arteries of the adjacent crus cerebri. The lateral rami vascularize the medial zone of the substantia nigra, then run along the lateral side of the red nucleus of which they are the main supply (Fig. 33, section X). Along their courses, branches from these arteries vascularize the medial lemniscus. Inferiorly in the mesencephalon (Fig. 32, section IX), they run along the lateral side of the superior cerebellar peduncle, of which they are, at this level, the main supply. Some arteries belonging to this group run through the superior cerebellar peduncle and form part of the vascular supply of the trochlear nucleus and of the adjacent medial longitudinal fasciculus.

b) Internal Territory of the Anteromedial Group of Mesencephalic Veins

The general distribution of the internal anteromedial veins is similar to that of the arteries. The comparative absence of veins from the median group of rami is to be noted; the existing ones (central interpeduncular veins of KHAN) are small in calibre and rarely drain the trochlear and oculomotor nuclei; branches from both sides of the mesencephalon frequently drain into one median vein (Fig. 33, section X).

In contrast, the veins belonging to the lateral rami of the intermediate pedicle of the interpeduncular fossa are larger and more numerous; their territory is comparable to that of the corresponding arteries.

c) Internal Territory of Anterolateral Groups of Mesencephalic Arteries

This group is composed of arteries which enter the crus cerebri (basal arteries of KHAN).

The arteries of this group mainly branch from the collicular and medial posterior choroidal arteries and, to a lesser extent, from the superior cerebellar, posterior cerebral and anterior choroidal arteries. They penetrate the nervous tissue mainly in the lower part of the crus cerebri near the pontomesencephalic sulcus (Fig. 32, section IX). Their upward course also makes them visible in Fig. 33, section X. Each artery of the anterolateral group is often so closely accompanied by a satellite vein that it is difficult to separate them. It is to be noted that several veins and arteries appear to be grouped into a small pedicle penetrating the lateral margin of the crus cerebri.

The arteries of the anterolateral group curve first towards, then away from, the median line as can be seen in Figs. 32 and 33, sections IX and X. The territory of the anterolateral group is extensive, the arteries supplying the crus cerebri and the substantia nigra (FINLEY 1936) Very frequently, the arteries go beyond the substantia nigra and reach the medial lemniscus posteriorly, and even the lateral part of the red nucleus.

A striking feature of these arteries is the contrast between the apparently small calibre of the superficial vessels and the extent of the territory they supply.

d) Internal Territory of the Anterolateral Group of Mesencephalic Veins

The description of the internal anterolateral veins (centrobasal vein of Khan) is similar in every detail to that of the arteries of which they are often close companions. One notable exception is the anastomosis (observed in two different cases) linking an internal anterolateral mesencephalic vein with a posterior pontine vein, thus traversing the upper part of the brain stem (Figs. 31 and 32, sections VIII and IX).

II. Internal Territories of the Lateral Groups of Mesencephalic Arteries and Veins

a) Internal Territory of the Lateral Group of Mesencephalic Arteries

The lateral group of arteries includes a large number of small arteries penetrating the lateral surface of the mesencephalon and the collicular brachia. These arteries arise, in ascending order, from the superior cerebellar, collicular and medial posterior choroidal arteries. The branches of the superior cerebellar arteries enter at the levels represented by Figs. 30 and 31, sections VII and VIII, and thus have been described together with the internal pontine vessels.

The internal lateral arteries have a curved course which is dorsally concave. Although they are very numerous, they vascularize a small territory, rarely more than the lateral lemniscus, the central tegmental tract and the surrounding reticular formation. These arteries rarely reach the medial longitudinal fasciculus, and there is no proof that they supply the trochlear and oculomotor nuclei. The arteries situated posteriorly in the groups, especially those which penetrate the collicular brachia, vascularize the lateral zone of the colliculi (Figs. 32 and 33, sections IX and X).

b) Internal Territory of the Lateral Group of Mesencephalic Veins

The internal lateral veins (central lateral veins of KHAN) have the same curved course as the arteries of the same group. They are often large and drain a larger territory than the arteries. The existence of several principal lateral veins (great dorsal tegmental vein of KHAN 1969) is to be noted (Figs. 32 and 33, sections IX and X). They drain not only the territory supplied by the arteries but also the trochlear and oculomotor nuclei, the posterior part of the red nucleus and sometimes the deep regions of the colliculi. There appears to be considerable variation in the extent of the territory drained by the lateral veins and the posterior veins, respectively.

III. Internal Territories of the Posterior Groups of Mesencephalic Arteries and Veins

The posterior group is mainly composed of the arteries and veins of the colliculi.

a) Internal Territory of the Posterior Group of Mesencephalic Arteries

The internal arteries of the posterior group arise from the dense and richly anastomotic superficial arterial network formed by the branches of the superior cerebellar, collicular and, to a lesser extent, medial posterior choroidal arteries (Figs. 32 and 33, sections IX and X). These small arteries enter the colliculi and then follow medially concave courses parallel to each other. They can be divided into two types: the shorter arteries which go no further than the middle zone of the colliculi, and the longer arteries, which traverse the colliculi and also vascularize the underlying periaqueductal grey matter. As already seen, the lateral group of arteries also supplies the lateral zone of the colliculi. Some small arteries, not consistently found, penetrate the recesses of the frenulum veli vascularizing the lower part of the colliculi and also the periaqueductal grey matter.

b) Internal Territory of the Posterior Group of Mesencephalic Veins

This group is formed by the internal veins of the colliculi which can be classified into two groups according to where they emerge from the brain stem: the peripheral collicular veins emerge from the surface of the colliculi and the central collicular veins emerge near the median line.

Peripheral Collicular Veins
(Figs. 32 and 33, sections IX and X)
These veins follow the same medially concave courses as the arteries to which they correspond. Like the latter, they can be divided into two types: the shorter veins draining the superficial and middle regions of the colliculi, and the longer veins. The longer veins have the following features: the branches emerge from the deep layers of the colliculus and run through the periaqueductal grey matter to form a venous trunk which traverses the colliculus towards the superficial venous network. This gives the veins the general appearance of an inverted weeping willow (Fig. 33, section X).

Central Collicular Veins
These veins are usually large and can be divided into inferior, middle and superior central collicular veins.
Inferior Central Collicular Veins (Fig. 32, section IX). These veins emerge from the recesses of the frenulum veli. They appear to be the same as KHAN's caudal ependymal veins.

Middle Central Collicular Veins (Fig. 33, section X; Fig. 157). They are often large in calibre and drain a territory of considerable size. They run along the deep margin of the colliculus, draining the greater part of the periaqueductal grey matter and the colliculi and sometimes part of the oculomotor nucleus. The left and right veins join posterior to the cerebral aqueduct to form a large middle central collicular vein, which emerges in the vertical intercollicular sulcus and drains immediately into the superior median collicular vein.

Superior Central Collicular Vein (Fig. 33, section X). Superior to the veins just described is usually a single venous trunk situated either on the left or on the right. It drains the superior colliculus, and also the periaqueductal grey matter and the superior perimeter of the oculomotor nucleus. It emerges inferior to the pineal gland and enters into a venous arch which links, on the posterior commissure, the left and right lateral pineal veins. More rarely, two or more superior central collicular veins are present (KHAN's 'cranial ependymal veins').

IV. General Survey of the Internal Territories of the Mesencephalon (Figs. 32 and 33, sections IX and X)

a) Arterial Territories

The importance of the anteromedial and anterolateral arterial groups is characteristic of the mesencephalon, as it is of the pons. These arteries supply the crus cerebri, the substantia nigra, the medial lemniscus, the red nucleus and the trochlear and oculomotor nuclei. The lateral group serves a much smaller territory, supplying the lateral lemniscus and the central tegmental tract. The posterior group supplies the colliculi and part of periaqueductal grey matter.

b) Venous Territories

The territories drained by the veins do not correspond entirely to those of the corresponding arteries due to the frequent occurrence of principal veins which, when present, drain large areas at the expense of the other smaller veins. In this way, the principal lateral veins and the central collicular veins, when present, drain part of the red nucleus and almost all the trochlear and oculomotor nuclei.

V. Vascularization of Tracts and Nuclei

a) Tracts

The corticospinal tract is vascularized by the anterolateral group of arteries and veins. The lemnisci are vascularized by two groups: the medial lemniscus by the anterolateral and anteromedial groups, the lateral lemniscus by the lateral group (Fig. 32, section IX).

b) Nuclei

The red nucleus is mainly supplied by the anteromedial group. Sometimes however, some long arteries belonging to the anterolateral group supply it, after passing through the substantia nigra. The red nucleus is drained not only by the veins of the anteromedial and anterolateral groups but also by the principal lateral veins, when they exist (Fig. 33, section X).

The substantia nigra is mainly served by arteries and veins of the anterolateral group, with the exception of its medial part, which is vascularized by the arteries and veins of the anteromedial group (Fig. 32 and 33, sections IX and X).

The vascularization of the trochlear and oculomotor nuclei has been variously described. According to Duret (1874) and Stopford (1916 b), the arteries supplying these nuclei arise from the terminal part of the basilar artery, i.e. from the inferior pedicle of the interpeduncular fossa. Alezais et D'Astros (1892 b) and Khan (1969) consider them to be vascularized solely by the long arteries of the intermediate pedicles of the interpeduncular fossa, which are rami of the posterior cerebral artery.

The present observations confirm the descriptions of Alezais et D'Astros (1892 b) and of Khan (1969). It is, however, to be noted that the accessory trochlear nuclei, when present, are situated inferiorly in the pontine tegmentum (Pearson 1943), and are vascularized by the inferior pedicle which arises from the basilar artery.

The trochlear and oculomotor nuclei are drained partly by the veins of the anterior group but mainly by the veins of the lateral and posterior groups (sections IX and X).

The colliculi are vascularized by the arteries and veins of the posterior groups. As Gillilan (1964) noted, the lateral regions of the colliculi are served by the vessels of the lateral group.

Conclusions

The foregoing description of the superficial vessels and their internal rami shows that, unlike the large superficial arteries, which are subject to great variation, the small arterial branches have superficial courses, sites of entry and territories which vary little from one subject to another. This relative constancy has often been noted (Duret 1874; Stopford 1916 a, b; Foix and Hillemand 1925 a–c; Gillilan 1964; Stephens and Stilwell 1969; Lazorthes et al. 1976), but it is far from being absolute. Variations, small but numerous, occur in both the superficial course and the territorial extent of the small arterial branches. These variations can be observed not only in separate brains but also between the two sides of the same brain. Nuclei and tracts, especially those of considerable longitudinal extent, are rarely supplied by a single arterial group, and the relative importance of the different groups supplying any nucleus or tract may vary.

These conclusions apply also to the veins, with the added feature of a greater variation in their internal courses due to the frequent existence of principal veins, which may take over the territories normally drained by neighbouring veins.

In the brain stem, the veins and arteries rarely ramify together with the exception of those in the crus cerebri. Not only are the courses of the arteries and veins usually different but they also usually vascularize different parts of the same nucleus or region. Thus, for example, in the medulla, the main arterial supply is from anterior groups whereas the drainage is through the lateral and posterior groups. The main arterial supply of the colliculi can be observed to be from the surface of this nuclei whereas the main drainage is from the deeper regions of the nuclei to the inferior, middle and superior central collicular veins. This polarity can be observed even in extremely small nervous centres such as the area postrema (Duvernoy et al. 1972) and the lamina terminalis (Duvernoy et al. 1969).

Vascular Anastomoses in the Brain Stem

In this chapter, numerous anastomoses between the vessels of the brain stem have been described. They can be divided into superficial and internal anastomoses and further subdivided as arterial, venous and arteriovenous.

Superficial arterial anastomoses: these anastomoses frequently occur between arteries belonging to the same group, more rarely between those of separate groups. The frequency of anastomoses varies considerably, not only from one brain stem to another, but also from one part of the brain stem to another within the same brain.

Superficial venous anastomoses: anastomoses between the superficial veins are even more frequent than arterial anastomoses, and they establish a large anastomotic network covering the brain stem.

Superficial arteriovenous anastomoses: no superficial arteriovenous anastomoses were observed in this study of the brain stem; this confirms Khan's (1969) findings for the midbrain. Scharrer (1940), who described the vascularization of the brain as a whole, also found no arteriovenous anastomoses, unlike Pfeifer (1930), who described numerous anastomoses on the surface of the cerebral hemispheres.

Internal arterial anastomoses: no internal arterial anastomoses, either between arteries belonging to separate groups or between those of the same group, were present. Thus, the internal arteries of the brain stem can be classified with the other cerebral 'end arteries'. This confirms the observations of numerous workers (Scharrer 1940; Rowbotham and Little 1963; Saunders and Bell 1971; Duvernoy et al. 1981), but not those of Campbell (1938) or Solnitzky (1940) who described numerous anastomoses in the cerebral cortex of monkey and cat.

Internal venous anastomoses: apart from a few exceptions in the medulla and midbrain, no internal venous anastomoses were observed in the brain stem. As Khan (1969) stated, the internal veins are similar to the arteries in being 'end veins', which suggests a venous pathology of the brain stem comparable to the more commonly described arterial pathology. However, it must be emphasized that the drainage of each nucleus or tract is generally more diversified than the corresponding arterial supply. Thus, it is possible to envisage the substitution of one vein for another through the capillary network.

Internal arteriovenous anastomoses: Pfeifer (1928) has recorded the occurrence of numerous internal arteriovenous anastomoses. As in the case of the superficial arteriovenous anastomoses, his observations were sharply criticized by Scharrer (1940), who found neither internal nor superficial arteriovenous anastomoses. The present observations in ten brain stems entirely confirm Scharrer's denial of such arteriovenous anastomoses. It must be noted, however that the present observations do not exclude the possibility of the precapillary arteriovenous anastomoses observed in the cerebral cortex in some mammalian species (Hasegawa et al. 1967; Duvernoy et al. 1981, 1983) and in the primary plexus of the hypophyseal portal system in the dog (Duvernoy 1972).

Figures 20–33 show the superficial and internal routes of the veins and arteries of the brain stem studied together. These illustrations are not taken from the joint observations of different brain stems but are a precise reproduction of one brain stem which appeared to be a particularly representative specimen.

Figures 20 and 21 are inside the back cover as folding plates. Together with Figs. 22 and 23, they illustrate the superficial arrangement of arteries and veins. The brain stem has been arbitrarily divided into ten levels (sections I–X).

For a better use of the drawings, the reader may examine closely the superficial vessels on the anterior and posterior views (Figs. 20 and 21 inside the back cover) which must be opened out, and on the lateral views (Figs. 22 and 23). The internal course of the superficial vessels will then be followed in the nervous tissue by the observation of the corresponding section. Some blood vessels may leave the section level to reach the neighbouring sections where they can be followed. Inset drawings are added to each of the ten sections in order to specify the arterial and venous territories (see also Figs. 178–187, and Gillilan 1964; Savoiardo et al. 1987; Duvernoy 1995; Tatu et al. 1996). These arterial and venous territories are determined from the brain stem studied and can be, of course, the subject of variations.

In order to identify the veins and arteries in the corresponding sections and to follow their deep route, each vessel has been numbered and represented by a colour code: the colour code used for the arteries of the medulla and the pons is not the same as that used for the mesencephalon (in both colour codes, the veins are shown in black).

The colour code for the medullary and pontine arteries is based on the different groups to which these arteries belong:

- The arteries of the anterior group are shown in blue
- The arteries of the lateral group are shown:
- in green if they arise from the vertebral and basilar arteries
- in red if they arise from the cerebellar arteries
- The arteries of the posterior group are shown in red

The colour code for the mesencephalic arteries is much simpler; each artery and its branches being shown in a different colour:

- Red: superior cerebellar arteries
- Green: collicular arteries
- Blue: medial posterior choroidal, cerebral posterior and anterior choroidal arteries

Fig. 20 and 21 → see folding plates inside the back cover

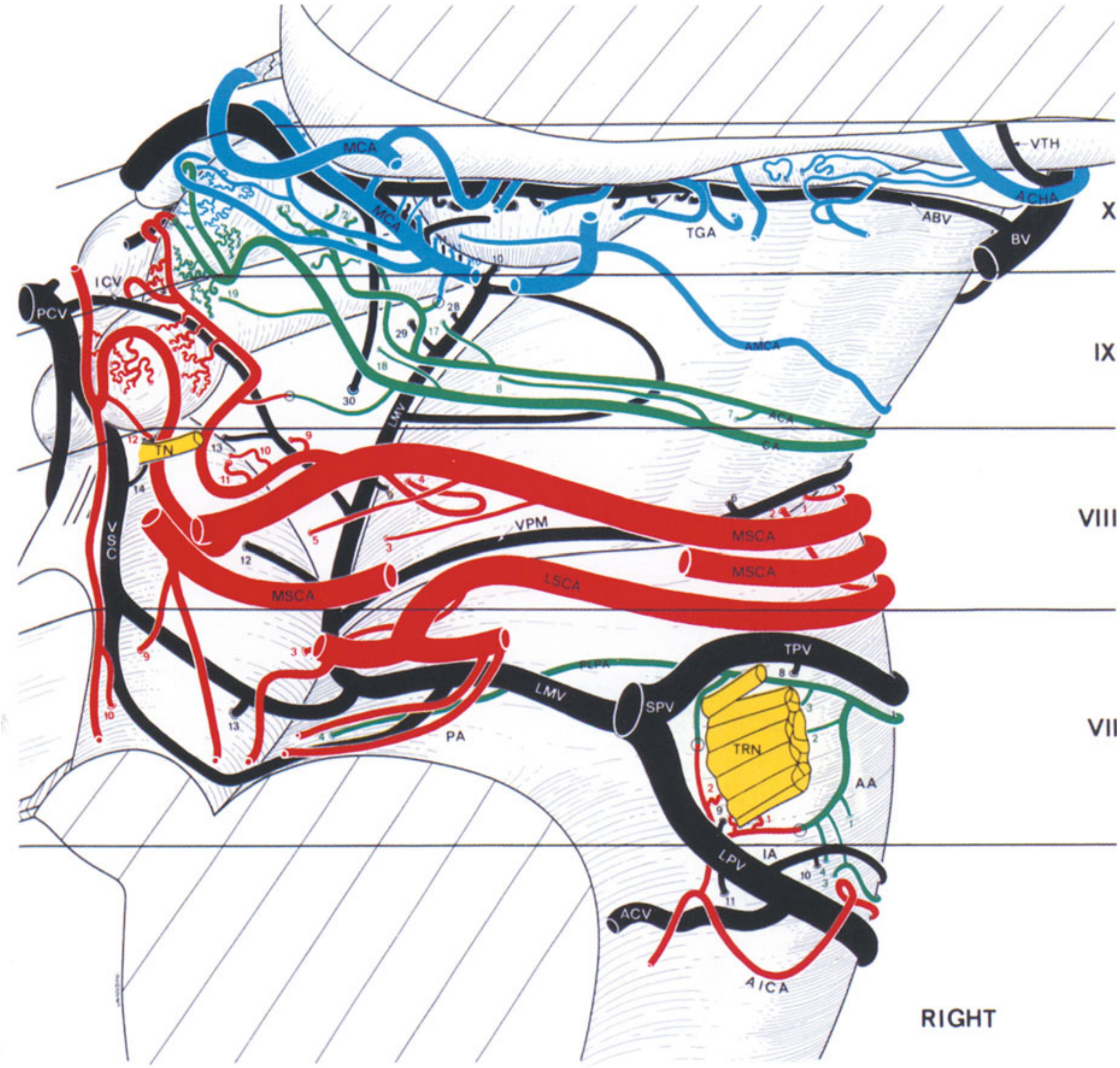


Fig. 22. Right Lateral View of the Mesencephalon. The internal course of the blood vessels numbered on this lateral view can be followed in the corresponding sections VII to X

AA	Anterior area of the lateral surface of the pons (see p. 40)
ABV	Accessory basal vein
ACA	Accessory collicular artery
ACHA	Anterior choroidal artery
ACV	Anterior cerebellar vein
AICA	Anterior inferior cerebellar artery
AMCA	Accessory medial posterior choroidal artery
BV	Basal vein
CA	Collicular artery
IA	Inferior area of the lateral surface of the pons (see p. 40)
ICV	Intercollicular vein
LMV	Lateral mesencephalic vein
LPV	Lateral pontine vein
LSCA	Lateral superior cerebellar artery
MCA	Medial posterior choroidal artery
MSCA	Medial superior cerebellar artery
PA	Posterior area of the lateral surface of the pons (see p. 41)
PCV	Precentral vein
PLPA	Posterolateral pontine artery
SPV	Superior petrosal vein
TGA	Thalamogeniculate arteries
TN	Trochlear nerve
TPV	Transverse pontine veins
TRN	Trigeminal nerve
VSC	Vein of the superior cerebellar peduncle (vein of the brachium conjunctivum)
VPM	Vein of the pontomesencephalic sulcus
VTH	Vein of the inferior (temporal) horn of the lateral ventricle
○	Superficial arterial anastomoses

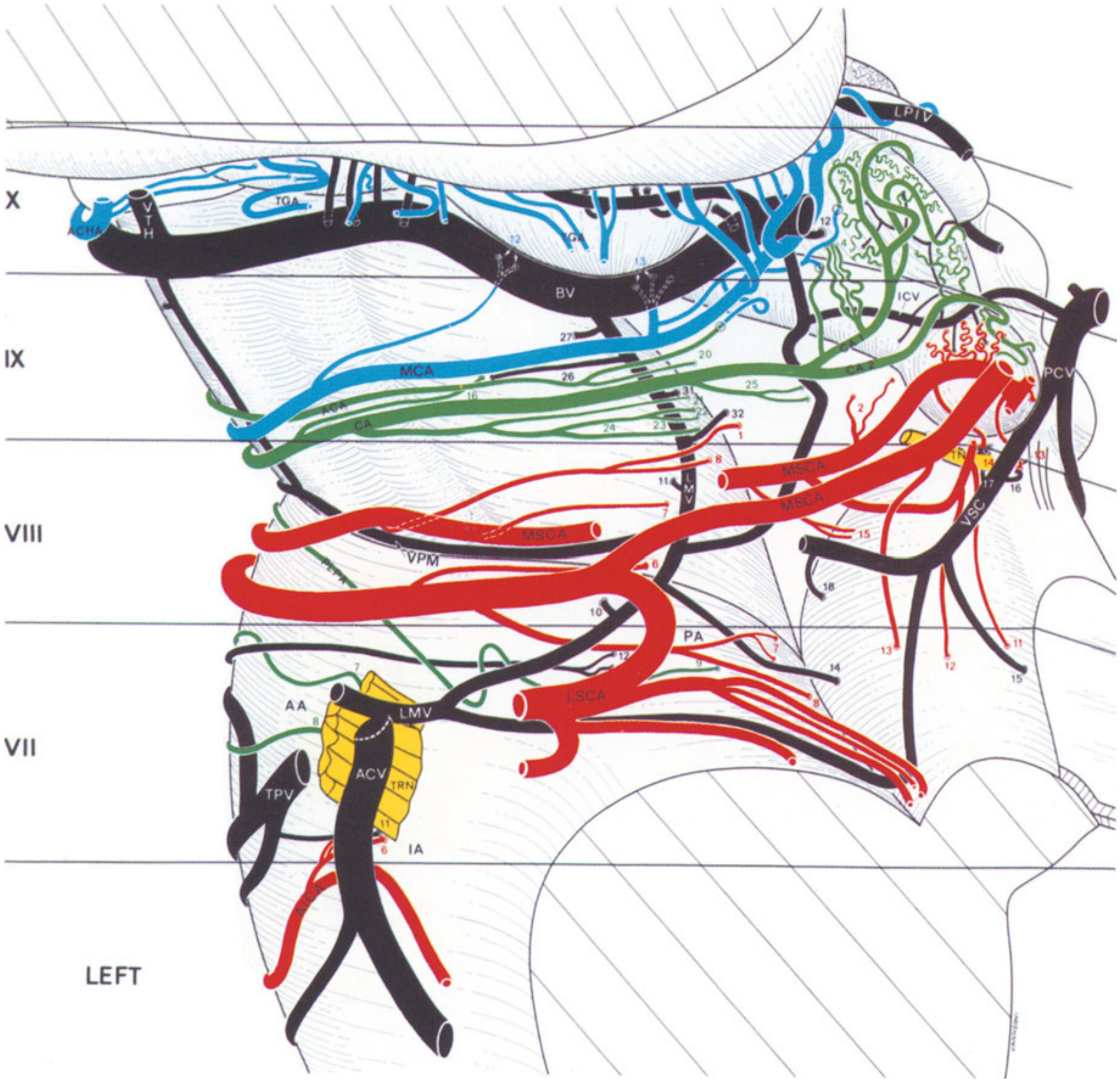
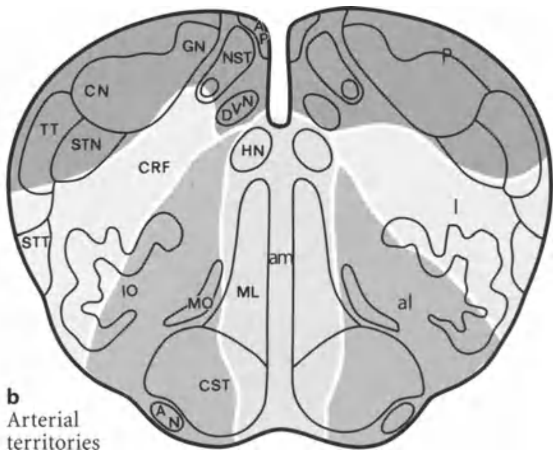
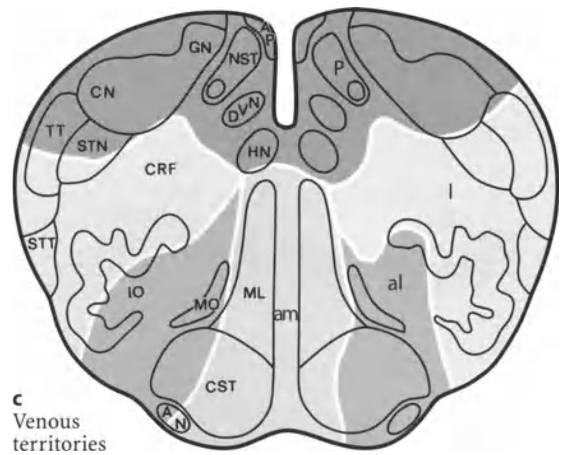


Fig. 23. Left Lateral View of the Mesencephalon. The internal course of the blood vessels numbered on this lateral view can be followed in the corresponding sections VII to X

ACA	Accessory collicular artery
ACHA	Anterior choroidal artery
ACV	Anterior cerebellar vein
AICA	Anterior inferior cerebellar artery
BV	Basal vein
CA	Collicular artery
CA1	Superior terminal branch of the collicular artery
CA2	Inferior terminal branch
IA	Inferior area of the lateral surface of the pons (see p. 40)
ICV	Intercollicular vein
LMV	Lateral mesencephalic vein
LPIV	Lateral pineal vein
AA	Anterior area of the lateral surface of the pons (see p. 40)
LSCA	Lateral superior cerebellar artery
MCA	Medial posterior choroidal artery
MSCA	Medial superior cerebellar artery
PA	Posterior area of the lateral surface of the pons (see p. 41)
PCV	Precentral vein
PLPA	Posterolateral pontine artery
TGA	Thalamogeniculate arteries
TN	Trochlear nerve
TPV	Transverse pontine veins
TRN	Trigeminal nerve
VSC	Vein of the superior cerebellar peduncle (vein of the brachium conjunctivum)
VPM	Vein of the pontomesencephalic sulcus
VTH	Vein of the inferior (temporal) horn of the lateral ventricle
○	Superficial arterial anastomoses



b
Arterial territories



c
Venous territories

Fig. 24. (section I) Transverse Section of the Medulla Oblongata (lower level). Internal Courses of the Arteries and Veins. The superficial arrangement of the arteries and veins can be followed on the anterior and posterior views of the brain stem (Figs. 20 and 21)

The inset drawings (**b** and **c**) delineate the territories vascularized by arteries and veins:

am: Territory of the anteromedial group
al: Territory of the anterolateral group
l: Territory of the lateral group
p: Territory of the posterior group

I. Anterior groups
A. Anteromedial group: arteries *1*, *2*, *3* (anterior spinal arteries); veins *1* (reaching the median anterior medullary vein)
B. Anterolateral group. Right: arteries *4* (anterior spinal arteries), *1* (posterior inferior cerebellar artery); veins: *2* central olivary vein reaching the lateral anterior medullary (preolivary) vein. Left: arteries *5* (anterior spinal arteries), *1*, *2* (vertebral artery); veins *3* and *4*

II. Lateral group
Right: arteries *2* (posterior inferior cerebellar artery); veins *5* principal lateral vein reaching this section from section II above
Left: arteries *3* (vertebral artery); veins *6* reaching the lateral medullary vein

III. Posterior group
Arteries *3*, *4*, *5*, *6*, *7*, *8*, *9*, *10* (posterior spinal arteries); veins *7*, *9*; *8* internal median posterior medullary vein (vein of the obex)

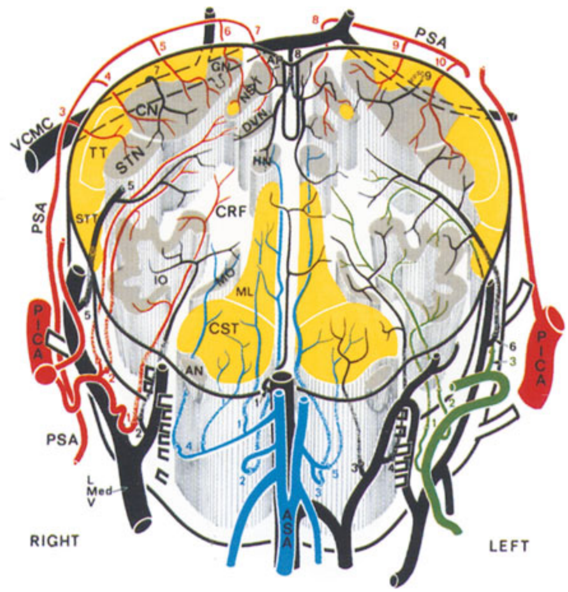


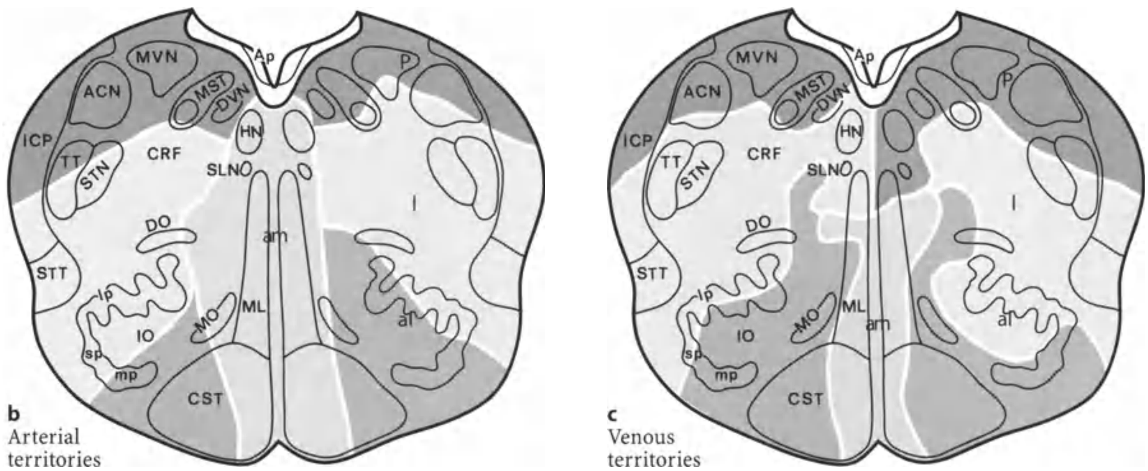
Fig. 24a

Superficial vessels

ASA	Anterior spinal artery
LMEDV	Lateral medullary vein
PICA	Posterior inferior cerebellar artery
PSA	Posterior spinal artery
VCMC	Vein of the cerebellomedullary cistern

Tracts and Nuclei

AN	Arcuate nucleus
AP	Area postrema
CN	Cuneate nucleus
CRF	Central reticular formation
CST	Corticospinal tract
DVN	Dorsal motor vagal nucleus
GN	Gracile nucleus
HN	Hypoglossal nucleus
IO	Inferior olivary nucleus
ML	Medial lemniscus
MO	Medial accessory olivary nucleus
NST	Nucleus of the solitary tract
STN	Spinal trigeminal nucleus
STT	Spinothalamic tract
TT	Spinal trigeminal tract



b Arterial territories

c Venous territories

Fig. 25. (section II) Transverse Section of the Medulla Oblongata (at the level of inferior olivary pole). Internal Courses of the Arteries and Veins. The superficial arrangement of the arteries and veins can be followed on the anterior and posterior views of the brain stem (Figs. 20 and 21)

The inset drawings (**b** and **c**) delineate the territories vascularized by arteries and veins:

am: Territory of the anteromedial group
al: Territory of the anterolateral group
l: Territory of the lateral group
p: Territory of the posterior group

I. Anterior groups

A. Anteromedial group: arteries *1*, *2* long arteries; *3* (anterior spinal arteries); veins *1* reaching the median anterior medullary vein

B. Anterolateral group: Right: arteries *4*, *5* (anterior spinal arteries), *1* (posterior inferior cerebellar artery); veins *2*; *3* central olivary vein (draining into the lateral anterior medullary vein, see p. 38)

Left: arteries *6* (anterior spinal arteries), *7* supplying the superficial part of the olive; veins *4* (deep anastomosis with *1*)

II. Lateral group

Right: arteries (inferior rami of the lateral medullary fossa) *2*, *3* (posterior inferior cerebellar artery), *1* (vertebral artery); veins *6*, *7*, *8* draining into the lateral medullary vein; *5* (I) principal lateral vein, leaving this section for section I below.

Left: arteries (inferior rami of the lateral medullary fossa) *8* medially situated (anterior spinal arteries) *2*, *3* centrally situated, *4* laterally situated (vertebral artery). Veins *9*, *11*; *10* central olivary vein (a tributary of the lateral medullary vein)

III. Posterior group

Arteries *4*, *5*, *6*, *7*, *8*, *9*, *11*, *12*, *13*; 10 leaving this section for section III above (posterior inferior cerebellar artery); veins (internal lateral posterior medullary veins) *12*, *15* (reaching this section from section III above) *13*, *14*; *16* veins reaching the marginal vein of the floor of the fourth ventricle

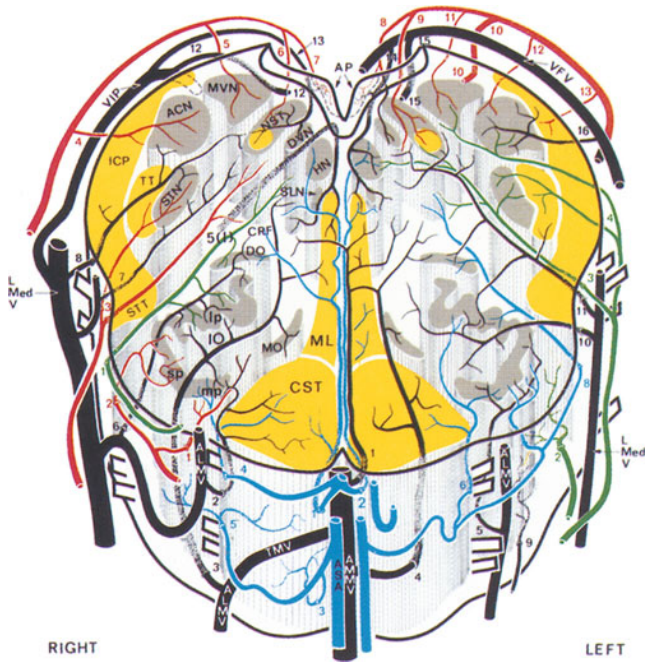


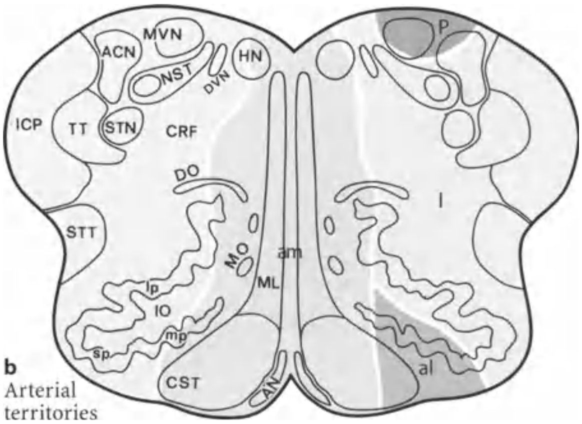
Fig. 25a

Superficial vessels

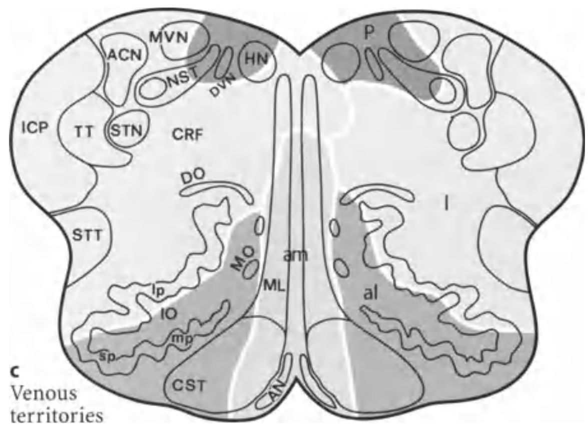
ALMV	Lateral anterior medullary vein
AMMV	Median anterior medullary vein
ASA	Anterior spinal artery
LMEDV	Lateral medullary vein
TMV	Transverse medullary veins
VFV	Marginal vein of the floor of the fourth ventricle
VIP	Vein of the inferior cerebellar peduncle

Tracts and Nuclei

ACN	Accessory cuneate nucleus
AP	Area postrema
CRF	Central reticular formation
CST	Corticospinal tract
DO	Dorsal accessory olivary nucleus
DVN	Dorsal motor vagal nucleus
HN	Hypoglossal nucleus
ICP	Inferior cerebellar peduncle
IO	Inferior olivary nucleus
lp	– lateral part
sp	– superficial part
mp	– medial part
ML	Medial lemniscus
MO	Medial accessory olivary nucleus
MVN	Medial vestibular nucleus
NST	Nucleus of the solitary tract
SLN	Sublingual nucleus (of Roller)
STN	Spinal trigeminal nucleus
STT	Spinothalamic tract
TT	Spinal trigeminal tract



b
Arterial territories



c
Venous territories

Fig. 26. (section III) Transverse Section of the Medulla Oblongata (at the level of the middle part of the inferior olive). Internal Courses of the Arteries and Veins. The superficial arrangement of the arteries and veins can be followed on the anterior and posterior views of the brain stem (Figs. 20 and 21)

The inset drawings (**b** and **c**) delineate the territories vascularized by arteries and veins:

am: Territory of the anteromedial group
al: Territory of the anterolateral group
l: Territory of the lateral group
p: Territory of the posterior group

I. Anterior groups

A. Anteromedial group: arteries *1*, *2*, *5* short arteries *3*, *4* long arteries (anterior spinal arteries); veins *1* reaching the median anterior medullary vein

B. Anterolateral group. Right: arteries *1* (vertebral artery); veins *2*, *3*, *4* reaching the lateral anterior medullary vein

Left: arteries *6*, *7* (anterior spinal arteries); veins *5*, *6*, *7* reaching the lateral anterior medullary vein

II. Lateral group

Right: arteries: middle rami of the lateral medullary fossa (vertebral artery), *2* medially situated, *3* centrally situated, *4* laterally situated; posterior rami of the lateral medullary fossa (internal) *1*, *2* (anterior inferior cerebellar artery); veins *8*, *9*, *11*; *10* reaching the retro-olivary vein (principal lateral vein), *12* reaching the lateral medullary vein

Left: arteries: middle rami of the lateral medullary fossa *3* (arteries of the superficial part of the olive, see p. 38), *4* medially situated, *5* laterally situated (posterior inferior cerebellar artery), *5* centrally situated (vertebral artery), posterior rami of the lateral medullary fossa *6* (vertebral artery), *6* (posterior inferior cerebellar artery); veins *13*, *16* reaching the lateral medullary vein, *14*, *15* reaching the vein of the pontomedullary sulcus

III. Posterior group

Arteries *10* (II) reaching this section from section II below; veins *12* (II) and *15* (II) leaving this section for section II below

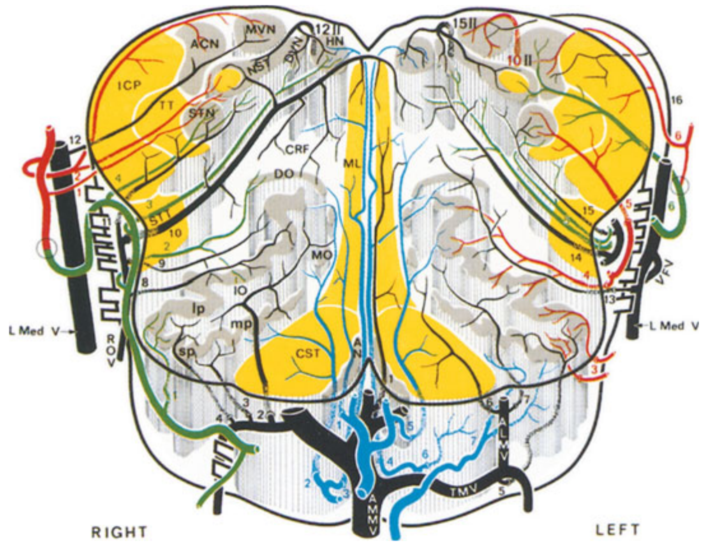


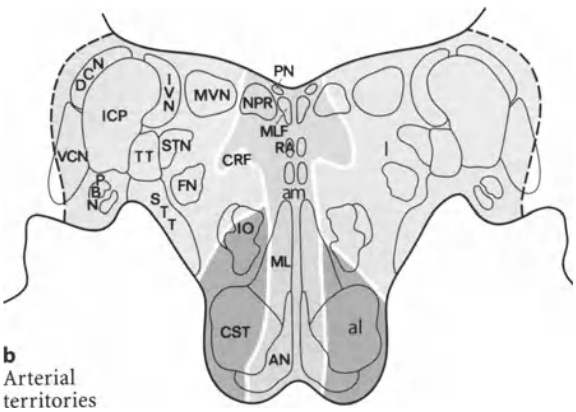
Fig. 26a

Superficial vessels

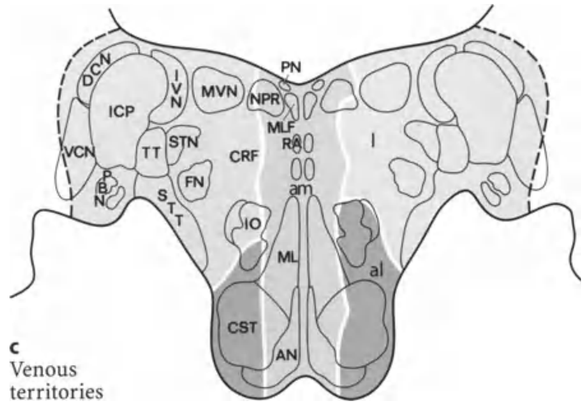
ALMV	Lateral anterior medullary vein
AMMV	Median anterior medullary vein
LMEDV	Lateral medullary vein
ROV	Retro-olivary vein
TMV	Transverse medullary vein
VFV	Marginal vein of the ventricular floor

Tracts and nuclei

ACN	Accessory cuneate nucleus
AN	Arcuate nucleus
CRF	Central reticular formation
CST	Corticospinal tract
DO	Dorsal accessory olivary nucleus
DVN	Dorsal motor vagal nucleus
HN	Hypoglossal nucleus
ICP	Inferior cerebellar peduncle
IO	Inferior olivary nucleus
lp	– lateral part
sp	– superficial part
mp	– medial part
ML	Medial lemniscus
MO	Medial accessory olivary nucleus
MVN	Medial vestibular nucleus
NST	Nucleus of the solitary tract
STN	Spinal trigeminal nucleus
STT	Spinothalamic tract
TT	Spinal trigeminal tract



b
Arterial territories



c
Venous territories

Fig. 27. (section IV) Transverse Section of the Medulla Oblongata (at the level of the superior olivary pole and of the pontomedullary sulcus). Internal Courses of the Arteries and Veins. The superficial arrangement of the arteries and veins can be followed on the anterior and posterior views of the brain stem (Figs. 20 and 21)

The inset drawings (**b** and **c**) delineate the territories vascularized by arteries and veins:

am: Territory of the anteromedial group
al: Territory of the anterolateral group
l: Lateral group

I. Anterior groups

A. Anteromedial group: arteries (arteries of the foramen caecum), *1*, *2* (basilar artery), *3* leaving this section for section V above; veins (Vein of the foramen caecum) *1* internal principal anteromedial vein

B. Anterolateral group: Right: arteries *4* (basilar artery); veins *2* reaching this section from section V above, *3*

Left: arteries *5* (basilar artery), *1* leaving this section for section V above; veins *4* reaching this section from section V above

II. Lateral group

Right: arteries superior rami of the lateral medullary fossa *2*, *3* leaving this section for section V above, *4*, *5* (basilar artery), *2*, *3* leaving this section for section V above, *1* (anterior inferior cerebellar artery), posterior rami of the lateral medullary fossa *4*, *5* (anterior inferior cerebellar artery); veins *5*, *6*, *8*, *9*; *7* reaching this section from section V above (these veins are branches of the vein of the pontomedullary sulcus), *10* subependymal vein of the lateral recess of the ventricle reaching this section from section V above (see p. 37)

Left: arteries superior rami of the lateral medullary fossa *6*, *7* (basilar artery), *6*, *7*, *8* leaving this section for section V above and supplying the lateral lower pontine tegmentum (anterior inferior cerebellar artery), posterior rami of the lateral medullary fossa *9*, *10* (anterior inferior cerebellar artery); veins *11*, *12*, *14*; *13* (branches of the vein of the pontomedullary sulcus) reaching this section from section V above, *15* subependymal vein of the lateral recess of the fourth ventricle (branch of the lateral medullary vein)

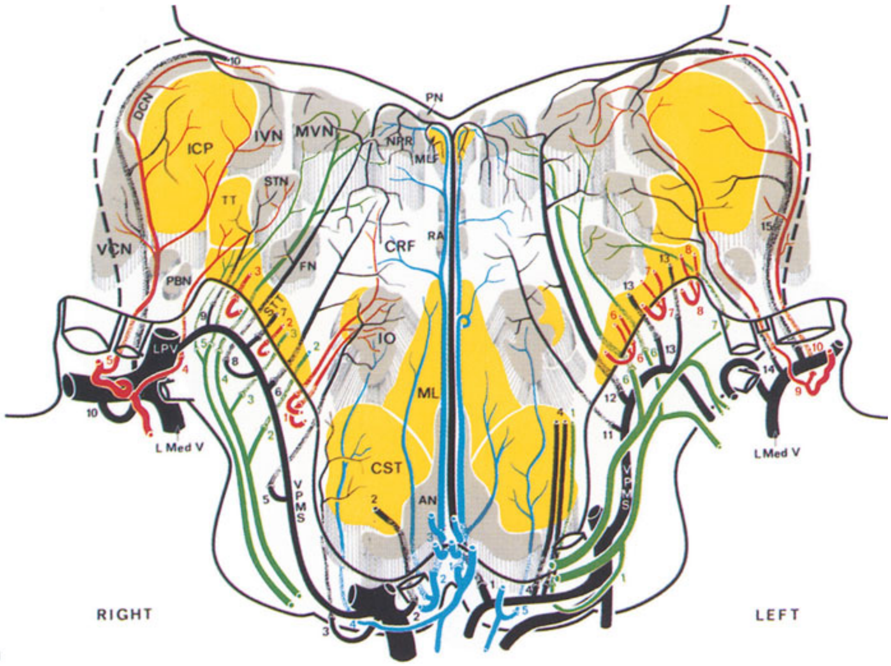


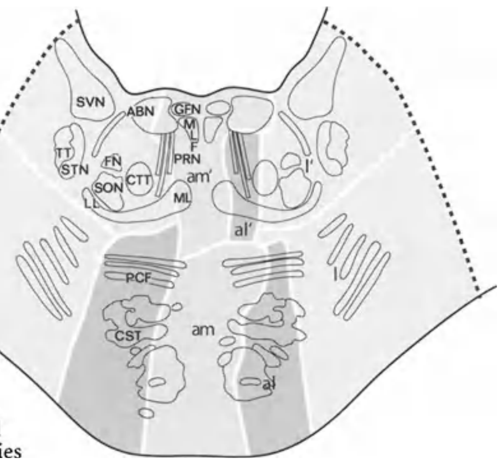
Fig. 27a

Superficial vessels

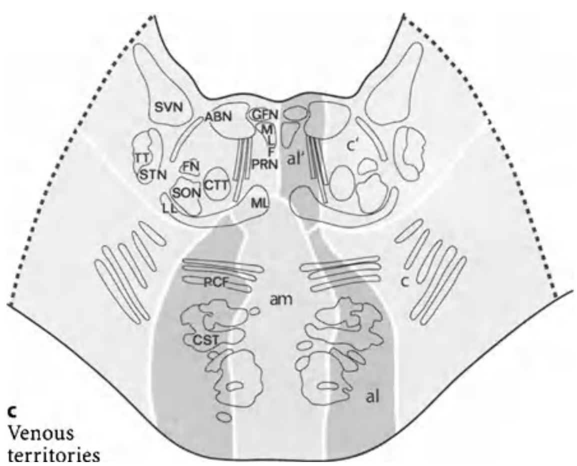
LMEDV	Lateral medullary vein
LPV	Lateral pontine vein
VPMS	Vein of the pontomedullary sulcus

Tracts and nuclei

AN	Arcuate nucleus
CRF	Central reticular formation
CST	Corticospinal tract
DCN	Dorsal cochlear nucleus
FN	Facial nucleus
ICP	Inferior cerebellar peduncle
IO	Inferior olivary nucleus
IVN	Inferior vestibular nucleus
ML	Medial lemniscus
MLF	Medial longitudinal fasciculus
MVN	Medial vestibular nucleus
NPR	Nucleus praepositus
PBN	Pontobulbar nucleus
PN	Paramedian nucleus
RA	Nucleus raphes
STN	Spinal trigeminal nucleus
STT	Spinothalamic tract
TT	Spinal trigeminal tract
VCN	Ventral cochlear nucleus



b
Arterial
territories



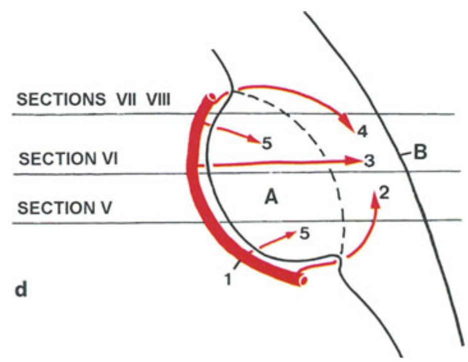
c
Venous
territories

Fig. 28. (section V) Transverse Section of the Pons *(*at lower level*)*. Internal Courses of the Arteries and Veins. The superficial arrangement of the arteries and veins can be followed on the anterior and posterior views of the brain stem (Figs. 20 and 21)

The inset drawings (**b** and **c**) delineate the territories vascularized by arteries and veins:
am, am': Territory of the anteromedial group
al, al': Territory of the anterolateral group
l, l': Territory of the lateral group

I. Anterior groups
A. Anteromedial group: arteries *1, 2, 3* short arteries (basilar artery) *3* (IV) artery of the foramen caecum reaching this section from section IV below and supplying the medial lower pontine tegmentum (am'); veins *1, 2* reaching the median anterior medullary vein
B. Anterolateral group. Right: arteries *4* (basilar artery), *1* (anterior inferior cerebellar artery); veins *3* internal principal anterolateral vein
Left: arteries *5, 6* (basilar artery), *1* (IV) reaching this section from section IV below (basilar artery); veins *4* reaching the lateral anterior pontine vein; (IV) *4* leaving this section for section IV below

II. Lateral groups
Right: arteries *1, 2* leaving this section for section VI above (inferior lateral pontine artery), *2* (IV), *3* (IV) reaching this section from section IV below (superior rami of the lateral medullary fossa: basilar artery) *2, 3* (anterior inferior cerebellar artery), *2* (IV), *3* (IV) reaching this section from section IV below (superior rami of the lateral medullary fossa: anterior inferior cerebellar artery and supplying the lateral lower pontine tegmentum l'); veins *5, 6* (internal principal lateral vein reaching the lateral pontine vein, (IV) *7* leaving this section for section IV below, (IV) *10* leaving this section for section IV below (subependymal vein of the lateral recess)
Left: arteries *3, 5; 4* leaving this section for section VI above, branches the inferior lateral pontine artery, *4* and *5* (anterior inferior cerebellar artery), *6* (IV), *7* (IV), *8* (IV) (superior rami of the lateral medullary fossa: anterior inferior cerebellar artery) reaching this section from section IV below and supplying the lateral lower pontine tegmentum (l'); veins *7* reaching this section from section IV above; *8, 9; 13* (IV) leaving this section for section IV below



d Sagittal Section of the Pons. Path of the arteries (and veins) supplying the pontine tegmentum: *A*, basilar part of the pons; *B*, pontine tegmentum; *1*, basilar artery; *2*, lower tegmentum (section V): the arteries (and veins) entering the pontomedullary sulcus (superior rami of the lateral medullary fossa) and the foramen caecum, supply the tegmentum by an ascending curved path; *3*, middle tegmentum (section VI) the arteries (and veins) have a straight course; *4*, upper tegmentum (sections VII and VIII): the arteries (and veins) entering the interpeduncular fossa, reach the tegmentum by a descending curved path; *5*, arteries supplying the basilar part of the pons

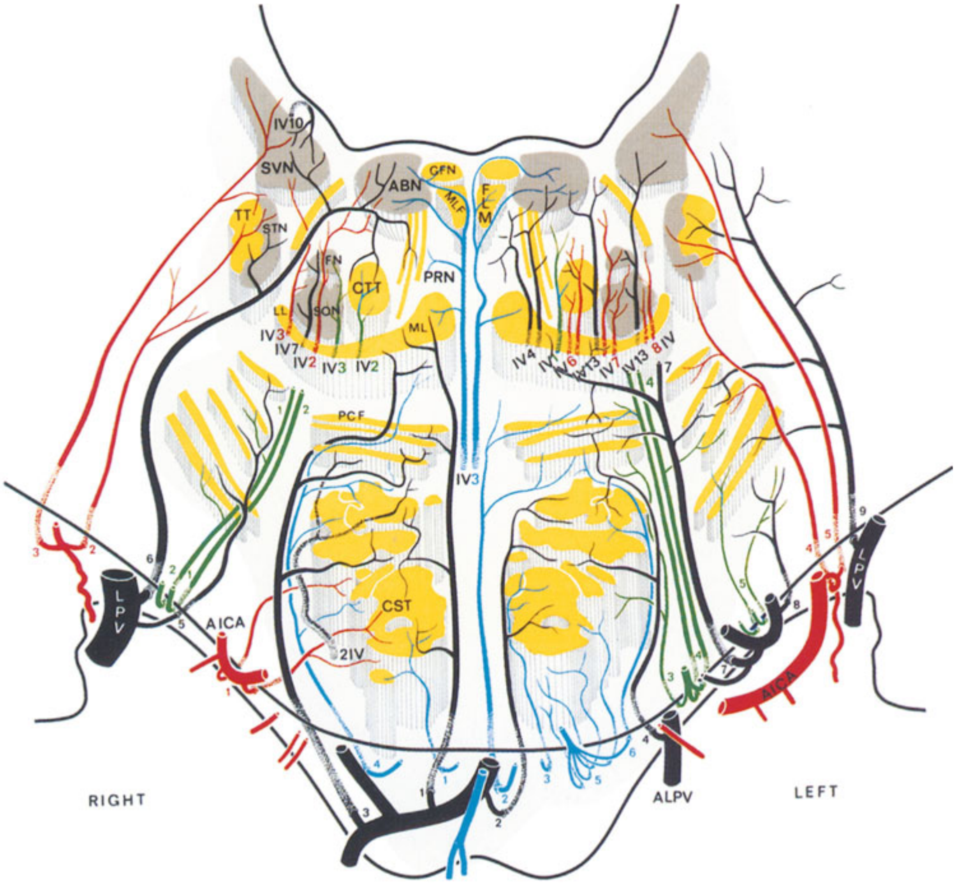


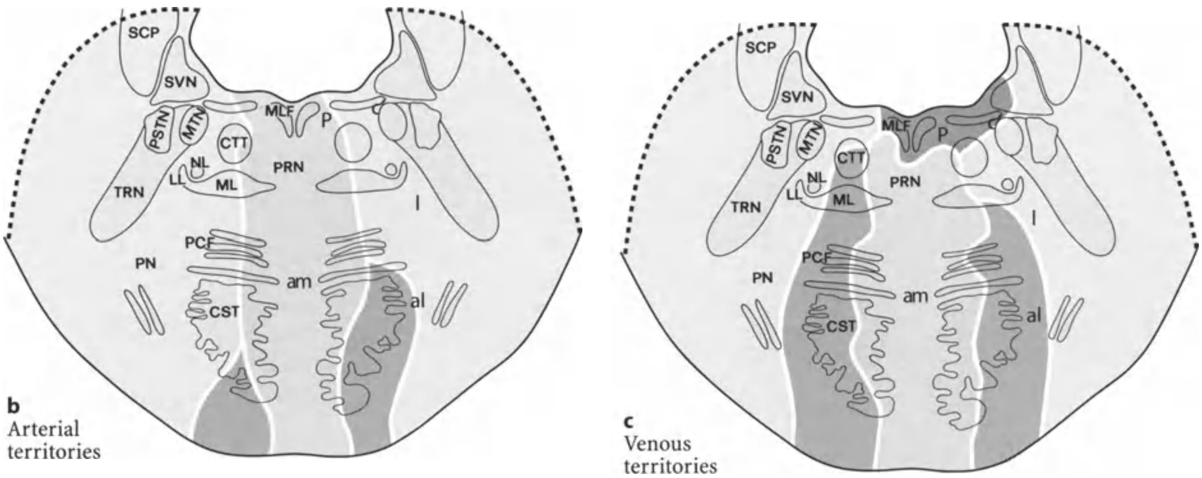
Fig. 28a

Superficial vessels

AICA	Anterior inferior cerebellar artery
ALPV	Anterior lateral pontine vein
LPV	Lateral pontine vein

Tracts and Nuclei

ABN	Abducent nucleus
CST	Corticospinal tract
CTT	Central tegmental tract
FN	Facial nucleus
GFN	Genu of the facial nerve
LL	Lateral lemniscus
ML	Medial lemniscus
MLF	Medial longitudinal fasciculus
PCF	Pontocerebellar fibers
PRN	Pontine reticular nuclei
SON	Superior olivary nucleus
STN	Spinal trigeminal nucleus
SVN	Superior vestibular nucleus
TT	Spinal trigeminal tract



b Arterial territories

c Venous territories

Fig. 29. (section VI) Transverse Section of the Pons (at middle level). Internal courses of the arteries and veins. The superficial arrangement of the arteries and veins can be followed on the anterior, posterior and lateral views of the brain stem (Figs. 20–23)

The inset drawings (**b** and **c**) delineate the territories vascularized by arteries and veins:

am: Territory of the anteromedial group
al: Territory of the anterolateral group
l: Territory of the lateral group
p: Territory of the posterior group

I. Anterior groups

A. Anteromedial group: arteries *1*, *3* long anteromedial arteries (basilar artery), *2* short anteromedial arteries (basilar artery); veins *1*, *2*, *3* reaching the median anterior pontine vein.
B. Anterolateral group. Right: arteries *4* (basilar artery); veins *4*; *5* internal principal anterolateral vein reaching the lateral anterior pontine vein. Left: arteries *5*, *6* (basilar artery), veins *6*; *7* internal principal anterolateral vein reaching a transverse pontine vein

II. Lateral groups

Arteries and veins of the anterior area of the lateral surface of the pons (*AA*, see p. 42): Right: arteries *1*, *2*, *3* (inferior lateral pontine artery), *4* (superior lateral pontine artery), *1* (V), *2* (V) reaching this section from section V below, *3* (VII) reaching this section from section VII above, *1* (VII), *2* (VII) reaching this section from section VII above and following the fibers of the trigeminal nerve; veins *8*, *9*, *10*, *11*; (VII) *8*, (VII) *9* leaving this section for section VII above
Left: arteries *5*, *6* (inferior lateral pontine artery) *7* (superior lateral pontine artery) *4* (V) reaching this section from section V below (inferior lateral pontine artery) *7* (VII), *8* (VII) reaching this section from section VII above (superior lateral pontine artery), *4* (VII), *5* (VII), *6* (VII) reaching this section from section VII above (anterior inferior cerebellar artery); veins *12*, *13* (reaching a transverse pontine vein); (VII) *11* leaving this section for section VII above

III. Posterior group

Veins (VII) *13* and (VII) *14* leaving this section for section VII above (subependymal pontine veins: inferior veins of the locus coeruleus)

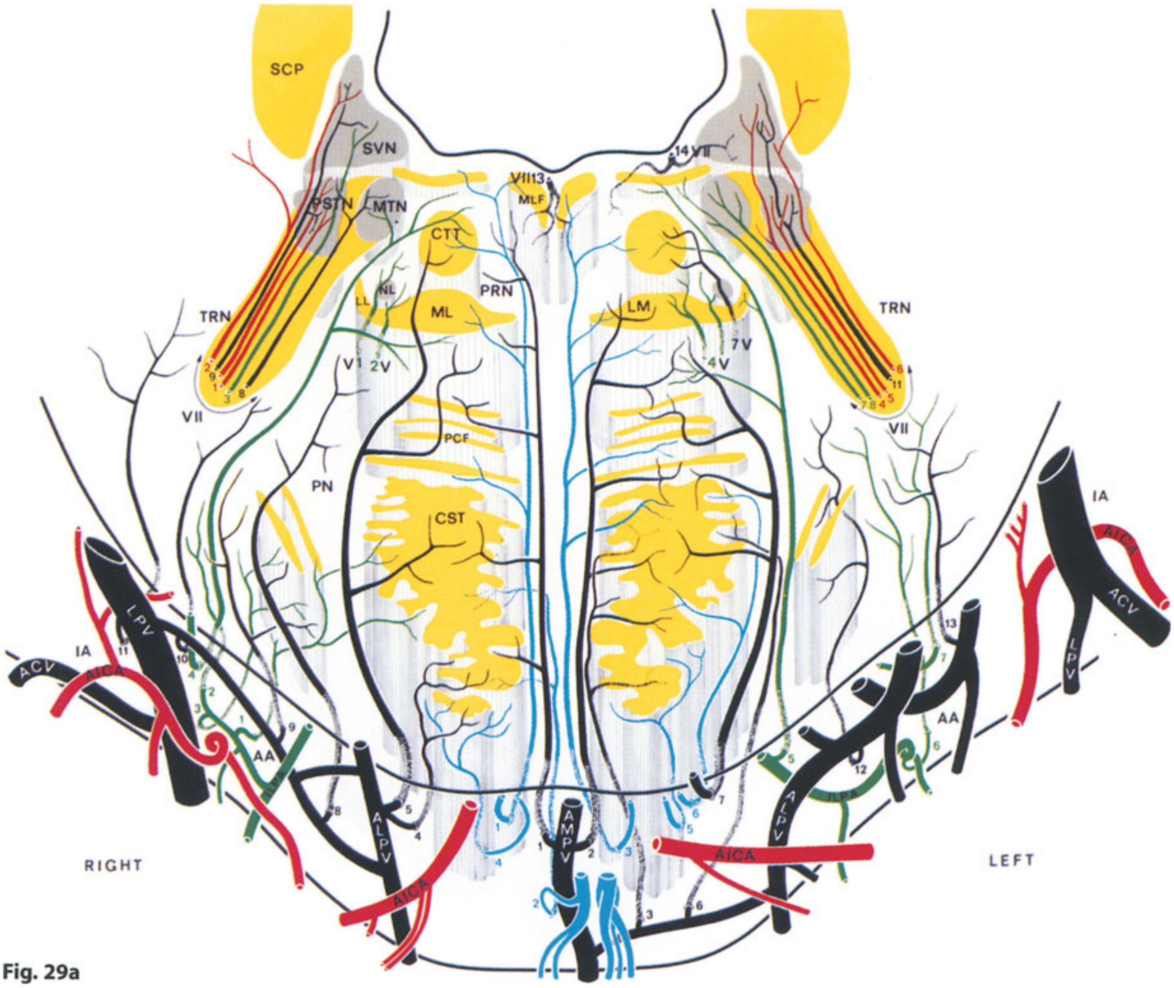


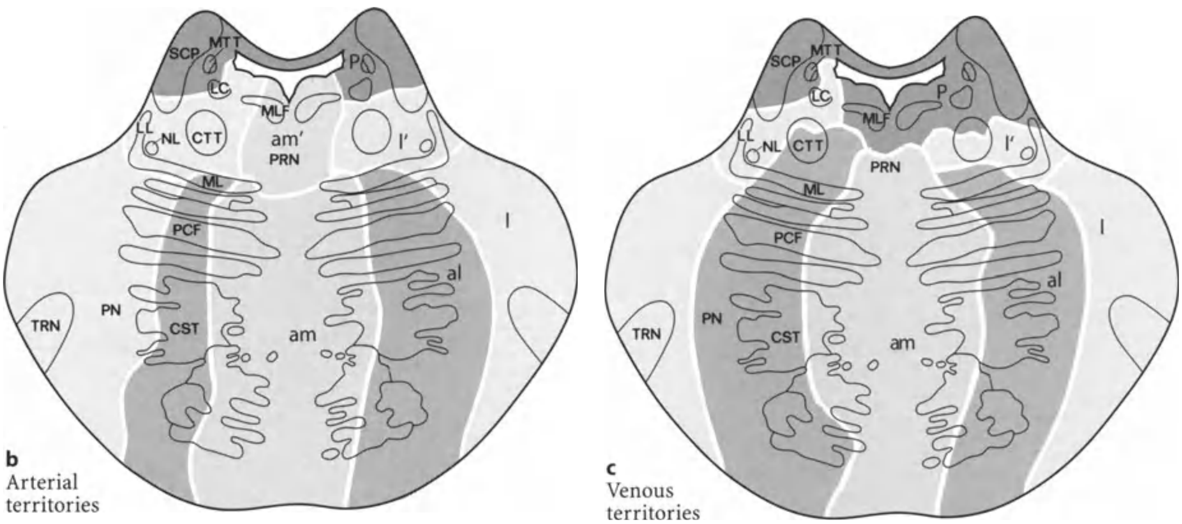
Fig. 29a

Superficial vessels

AA Anterior area of the lateral surface of the pons (see p. 40)
ACV Anterior cerebellar vein
AICA Anterior inferior cerebellar artery
ALPV Lateral anterior pontine vein
AMPV Median anterior pontine vein
IA Inferior area of the lateral surface of the pons (see p. 40)
ILPA Inferior lateral pontine artery
LPV Lateral pontine vein

Tracts and nuclei

CST Corticospinal tract
CTT Central tegmental tract
LL Lateral lemniscus
ML Medial lemniscus
MLF Medial longitudinal fasciculus
MTN Motor trigeminal nucleus
NL Nucleus of the lateral lemniscus
PCF Pontocerebellar fibers
PN Pontine nuclei
PRN Pontine reticular nuclei
PSTN Principal sensory trigeminal nucleus
SCP Superior cerebellar peduncle
SVN Superior vestibular nucleus
TRN Trigeminal nerve



b Arterial territories

c Venous territories

Fig. 30. (section VII) Transverse Section of the Pons (at upper level). Internal Courses of the Arteries and Veins. The superficial arrangement of the arteries and veins can be followed on the anterior, posterior and lateral views of the brain stem (Figs. 20–23)

The inset drawings (**b** and **c**) delineate the territories vascularized by arteries and veins:
am, am': Territory of the anteromedial group
al: Territory of the anterolateral group
l, l': Territory of the lateral group
p: Territory of the posterior group

I. Anterior groups
A. Anteromedial group: arteries *1, 2, 3, 4, 5, 6*, (basilar artery), *1* (VIII) reaching this section from section VIII above, *6* (IX) reaching this section from section IX (artery belonging to the inferior pedicle of the interpeduncular fossa) and supplying the upper pontine tegmentum (am'); veins *1, 2, 3* reaching the median anterior pontine vein. B. Anterolateral group
Right: arteries *7, 8* (basilar artery); veins *4, 5* (internal principal anterolateral vein) reaching a transverse pontine vein, (VIII) *6* (VIII) *5* leaving this section for section VIII above
Left: arteries *9, 10* (basilar artery); veins *6*; *7* internal principal anterolateral vein reaching a transverse pontine vein

II. Lateral groups
Right: a) Anterior area of the lateral surface of the pons (*AA*). Arteries *1, 2* (superior lateral pontine artery), *3* leaving this section for section VI below; veins *8* (branch of a transverse pontine vein) reaching this section from section VI below. b) Inferior area of the lateral surface of the pons (*IA*). Arteries *1, 2* (anterior inferior cerebellar artery) leaving this section for section VI below; vein *9* (branch of the lateral pontine vein) reaching this section from section VI below. c) Posterior area of the lateral surface of the pons (*PA*). Arteries *4* (posterolateral pontine artery), *3* (inferior lateral rami of the superior cerebellar artery (see p. 47), *3* (VIII) reaching this section from section VIII above (superior cerebellar artery); veins (VIII) *12* leaving this section for section VIII above (middle vein of the locus coeruleus)
Left: a) Anterior area of the lateral surface of the pons (*AA*). Arteries *5, 6, 7, 8* (superior lateral pontine artery); veins *10* reaching a transverse pontine vein. b) Inferior area of the lateral surface of the pons (*IA*). Arteries *4, 5, 6* (anterior inferior cerebellar artery) leaving this section from section VI below; vein *11* reaching this section from section VI below. c) Posterior area of the lateral surface of the pons (*PA*). Arteries *9* posterolateral pontine artery (see p. 41), *7, 8* inferior lateral rami of the superior cerebellar artery (see p. 47), *7* (VIII) reaching this section from section VIII above and supplying the upper external pontine tegmentum (l'); veins *12* reaching a transverse pontine vein; (VIII) *11* leaving this section for section VIII above

III. Posterior groups
Arteries *9, 10, 11, 12, 13* (medial superior cerebellar artery, see p. 47); veins *13* (branch of the vein of superior cerebellar peduncle) and *14*: inferior veins of the locus coeruleus (branches of the lateral mesencephalic vein (note their subependymal path on section VI below and on Fig. 21) *15*; (VIII) *18* leaving this section for section VIII above (middle vein of the locus coeruleus, branch of the vein of superior cerebellar peduncle)

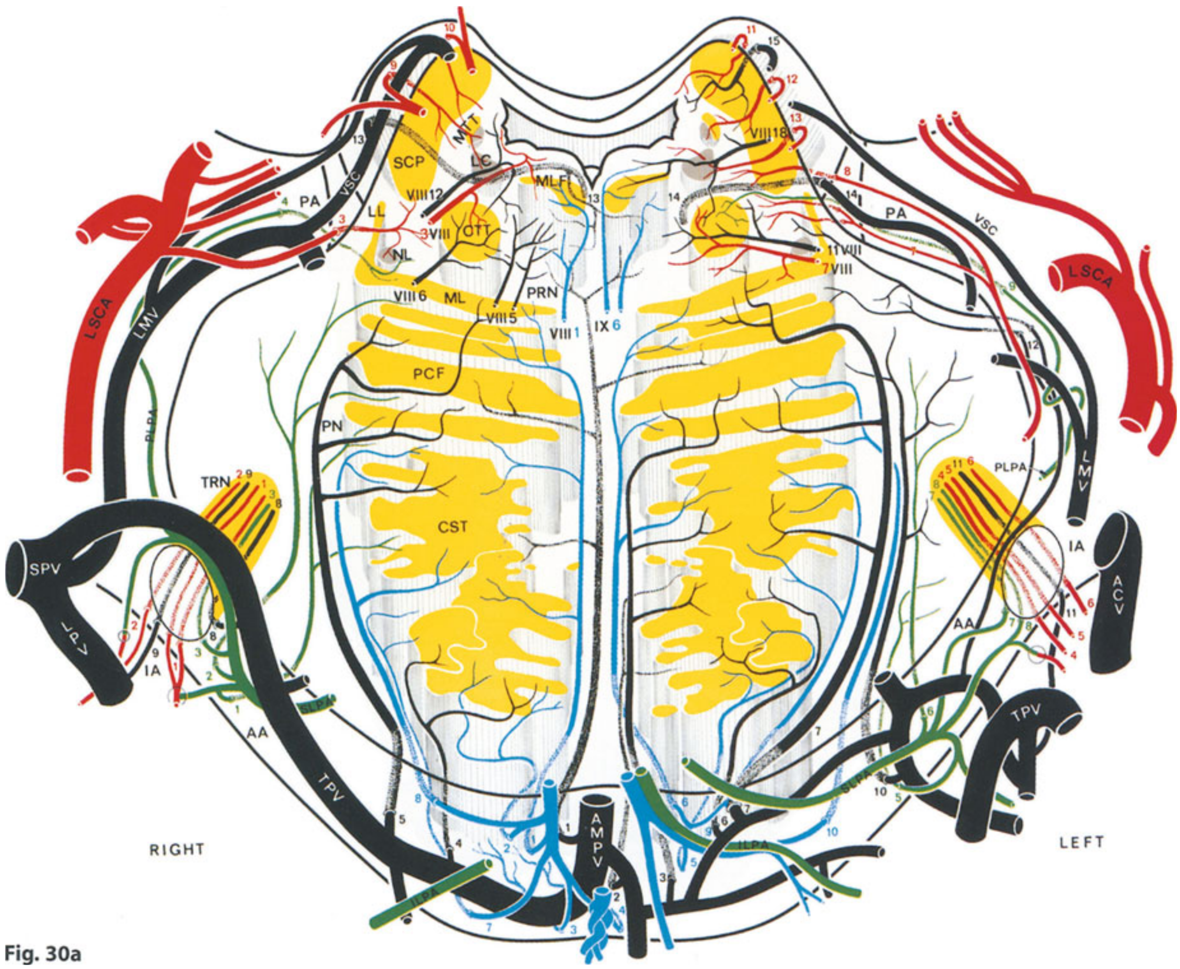


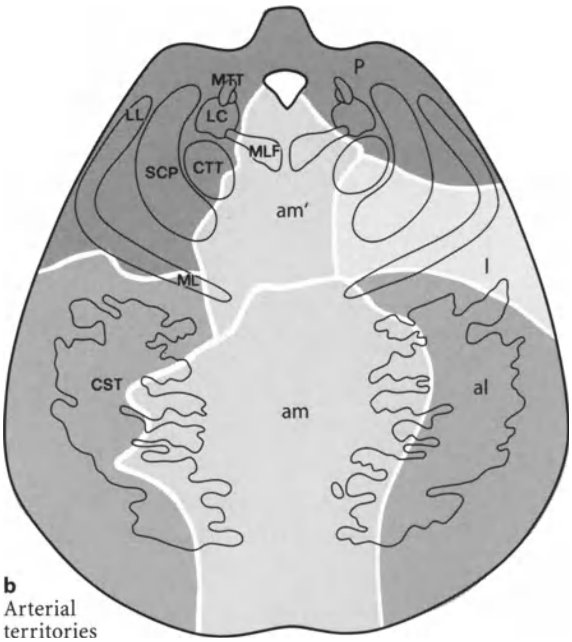
Fig. 30a

Superficial vessels

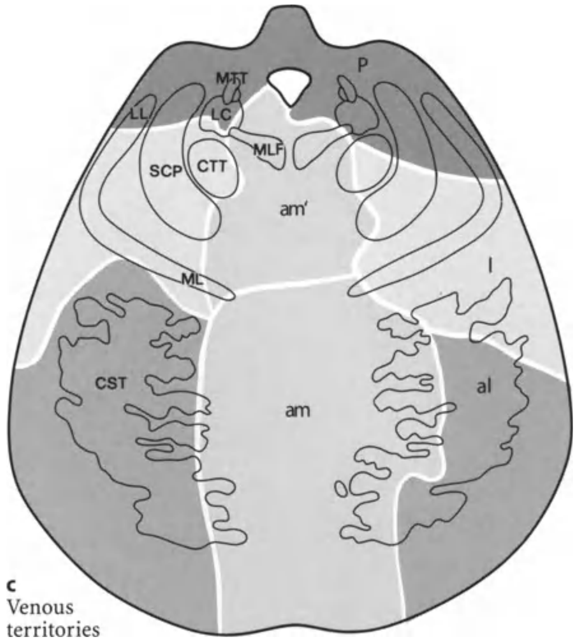
- *ACV* Anterior cerebellar vein
- *AMPV* Median anterior pontine vein
- *ILPA* Inferior lateral pontine artery
- *LMV* Lateral mesencephalic vein
- *LPV* Lateral pontine vein
- *LSCA* Lateral superior cerebellar artery
- *PLPA* Posterolateral pontine artery
- *SLPA* Superior lateral pontine artery
- *SPV* Superior petrosal vein
- *TPV* Transverse pontine vein
- *VSC* Veins of the superior cerebellar peduncle (vein of the brachium conjunctivum)
- *IA* Inferior area of the lateral surface of the pons
- *AA* Posterior area of the lateral surface of the pons
- *PA* Posterior area of the lateral surface of the pons

Tracts and Nuclei

- *CST* Corticospinal tract
- *CTT* Central tegmental tract
- *LC* Locus coeruleus
- *LL* Lateral lemniscus
- *ML* Medial lemniscus
- *MLF* Medial longitudinal fasciculus
- *MTT* Mesencephalic trigeminal tract
- *NL* Nucleus of the lateral lemniscus
- *PCF* Pontocerebellar fibers
- *PN* Pontine nuclei
- *PRN* Pontine reticular nuclei
- *SCP* Superior cerebellar peduncle
- *TRN* Trigeminal nerve



b
Arterial territories



c
Venous territories

Fig. 31. (section VIII) Transverse Section of the Pons (at upper level). Internal Courses of the Arteries and Veins. The superficial arrangement of the arteries and veins can be followed on the anterior, posterior and lateral views of the brain stem (Figs. 20–23)

The inset drawings (**b** and **c**) delineate the territories vascularized by arteries and veins:

am, am': Territory of the anteromedial group
al: Territory of the anterolateral group
l: Territory of the lateral group
p: Territory of the posterior group

I. Anterior groups

A. Anteromedial group: arteries *1* leaving this section for section VII below, *2*, *3*, *4* (basilar artery), *5* (IX), *6* (IX), *7* (IX) reaching this section from section IX above (inferior pedicle of the interpeduncular fossa) and supplying the upper pontine tegmentum (am'); veins *1*, *2*, *3* reaching the median anterior pontine vein; (IX) *6*, *5* and *7* leaving this section for section IX above (inferior pedicle of the interpeduncular fossa; branches of the interpeduncular veins)

B. Anterolateral group. Right: arteries *5*, *6*, *7*, *8* (basilar artery), *1*, *2* arteries of the pontomesencephalic sulcus (superior cerebellar artery); veins *4*, *5* and *6* reaching this section from section VII below

Left: arteries *9*, *10*, *11*, *12*, *13* (basilar artery); veins *7*, *8*

II. Lateral group

(*PA*, posterior area of the lateral surface of the pons, see p. 41)

Right: arteries *3* leaving this section for section VII below (medial superior cerebellar artery), *4*, *5* superior lateral rami of the superior cerebellar artery (see p. 47); veins *9* reaching the lateral mesencephalic vein

Left: arteries *7* leaving this section for section VII below, *6*, *8* superior lateral rami of the superior cerebellar artery; veins *10*, *11* reaching this section from section VII below (branch of the lateral mesencephalic vein)

III. Posterior groups

Arteries: *12*, *14* arteries of the infracollicular recesses, *9*, *10*, *11*, *15* (medial superior cerebellar arteries) *13* artery of the recess of the frenulum veli (medial superior cerebellar artery) leaving this section for section X above; veins: *12* (branch of lateral mesencephalic vein) reaching this section from section VII below; *13* middle vein of the locus coeruleus; *14* vein of the infracollicular recess (see p. 43) (superior vein of the locus coeruleus) reaching this section from section IX above (note its anastomosis with *14* in section IX), *15* and *16* reaching this section from section IX above: veins of the recesses of the frenulum veli or inferior central collicular veins; *17* vein of the infracollicular recess (superior vein of the locus coeruleus); *18* reaching this section from section VII below (middle vein of the locus coeruleus)

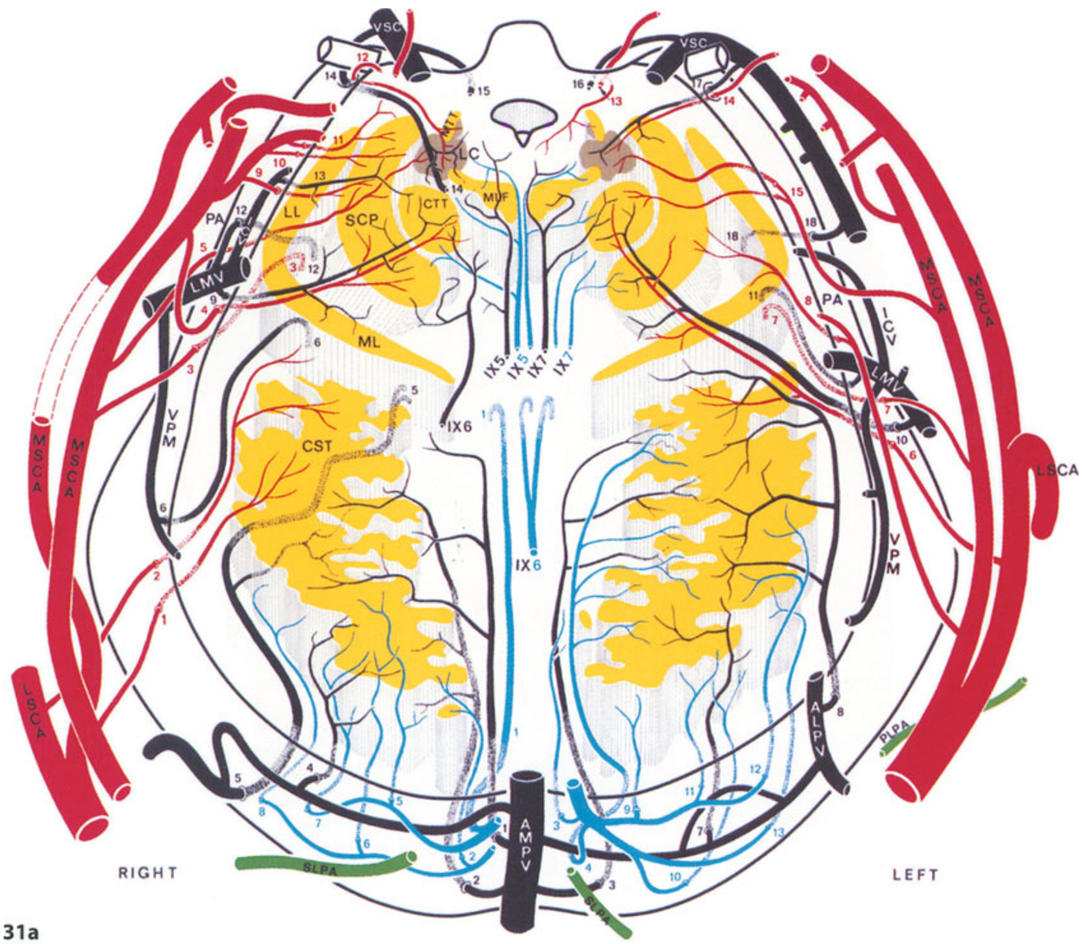


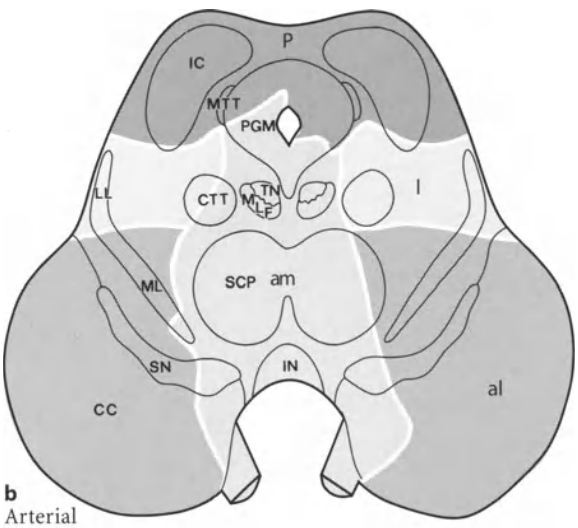
Fig. 31a

Superficial vessels

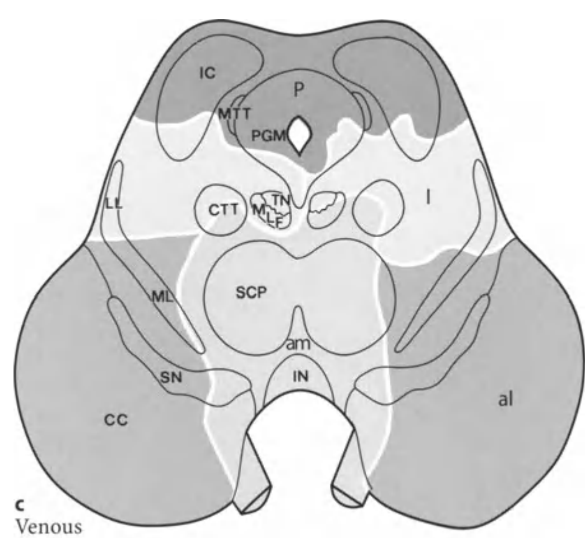
ALPV	Lateral anterior pontine vein
AMPV	Anterior median pontine vein
ICV	Intercollicular vein
LMV	Lateral mesencephalic vein
LSCA	Lateral superior cerebellar artery
MSCA	Medial superior cerebellar artery
PA	Posterior area of the lateral surface of the pons
PLPA	Posterior lateral pontine artery
SLPA	Superior lateral pontine artery
VPM	Vein of the pontomesencephalic sulcus
VSC	Vein of the superior cerebellar peduncle (vein of the brachium conjunctivum)

Tracts and Nuclei

CST	Corticospinal tract
CTT	Central tegmental tract
LC	Locus coeruleus
LL	Lateral lemniscus
ML	Medial lemniscus
MLF	Medial longitudinal fasciculus
MTT	Mesencephalic trigeminal tract
SCP	Superior cerebellar peduncle



b
Arterial territories



c
Venous territories

Fig. 32. (section IX). Transverse Section of the Mesencephalon (at inferior level). Internal Courses of the Arteries and Veins. The superficial arrangement of the arteries and veins can be followed on the anterior, posterior and lateral views of the brain stem (Figs. 20–23)

The inset drawings (**b** and **c**) delineate the territories vascularized by arteries and veins:

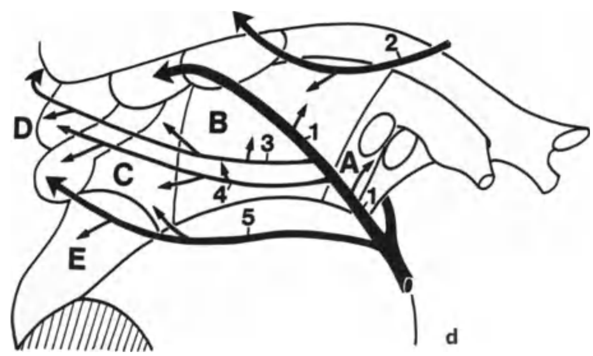
am: territory of the anteromedial group
al: territory of the anterolateral group
l: territory of the lateral group
p: territory of the posterior group

I. Anterior groups

A. Anteromedial group: arteries *1*, *1'* long arteries: median rami of the intermediate pedicle of the interpeduncular fossa (posterior cerebral artery); *2*, *3*, *4* lateral rami of the intermediate pedicle of the interpeduncular fossa (posterior cerebral artery) *5*, *6*, *7*, inferior pedicle of the interpeduncular fossa leaving this section for sections VIII and VII below (terminal segment of basilar artery), *1* belonging to the lateral rami of the intermediate pedicle of the interpeduncular fossa (collicular artery); veins: *1* belonging to the medial rami of the intermediate pedicle of the interpeduncular fossa *2*, *3*, *4* lateral rami of the intermediate pedicle of the interpeduncular fossa, *5*, *6*, *7* inferior pedicle of the interpeduncular fossa reaching this section from section VIII below (all these veins reach the interpeduncular veins)

B. Anterolateral group. Right: arteries *6*, *7* (collicular artery) *2*, *3*, *4*, *5*, *8* leaving this section for section X above (collicular artery), *8*, *9*, *10*, *11* arteries of the pontomesencephalic sulcus; veins *9*, *11*, *12*, *13* reaching this section from section X above, *8*, *10*; *14* note its anastomosis with (VIII)

Left: arteries *9*, *10*, *13*, *15* leaving this section for section X above (collicular artery), *11*, *12*, *14*, *16* (collicular artery), *12*, *13* leaving this section for section X above (medial posterior choroidal artery); veins *16*, *18*, *21*, *24*, *25*, *27* reaching this section from section X above, *17*, *19*, *20*, *22*, *23*, *26* (all these veins are branches of the basal vein)



d As the arteries supplying the mesencephalon have an oblique ascending course, the different groups of mesencephalic arteries usually arise from the main arterial trunks as follows:

- the anteromedial groups (arteries of the interpeduncular fossa, *A*, mainly arise from the posterior cerebral artery (*1*)
- the anterolateral group (arteries of the crus cerebri) (*B*) arise, in descending order, from the anterior choroidal (*2*), posterior cerebral (*1*) medial posterior choroidal (*3*) and collicular (*4*) arteries
- the arteries of the lateral group (*C*) arise in descending order from the medial posterior choroidal (*3*) collicular (*4*) and superior cerebellar (*5*) arteries
- the arteries of the posterior group (mesencephalic tectum or collicular region, *D*) arise in descending order from the medial posterior choroidal (*3*), collicular (*4*), and superior cerebellar (*5*) arteries

The superior cerebellar peduncle (*E*) (posterior group of pontine arteries) is mainly supplied by the superior cerebellar artery (*5*)

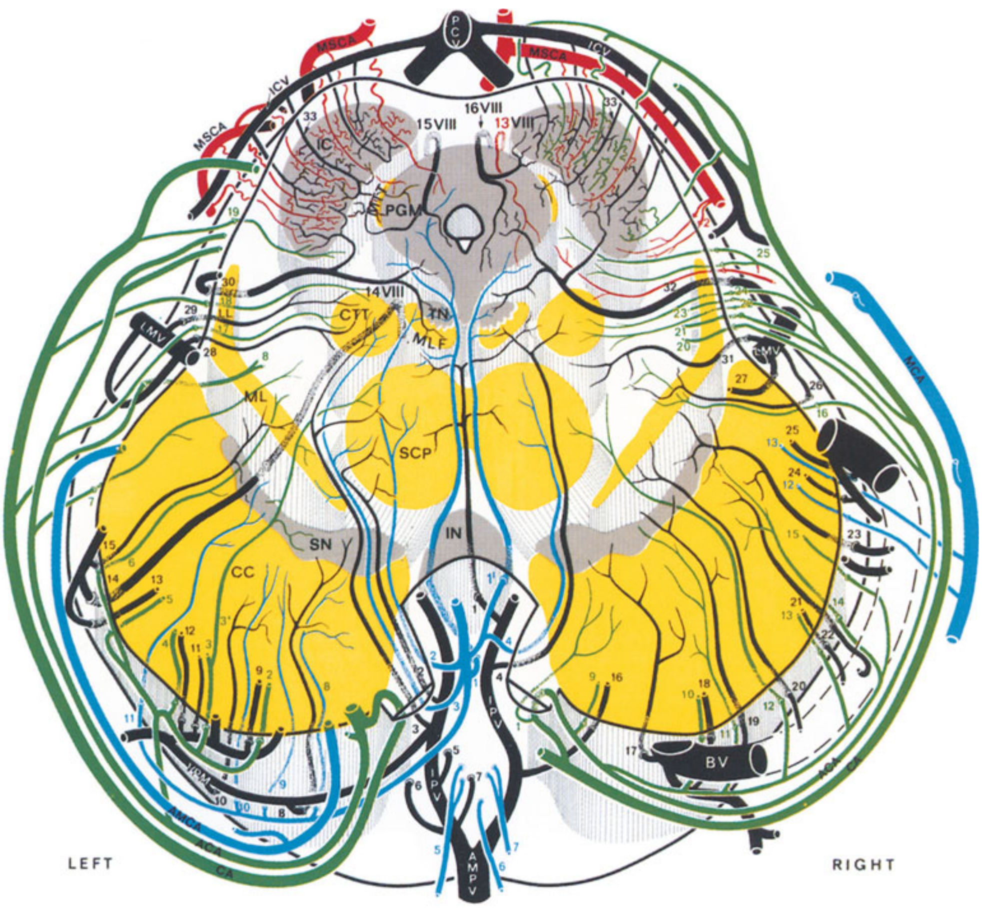


Fig. 32a

II. Lateral groups
Right: arteries: *19* artery of the inferior collicular brachium, *17*, *18* (collicular artery); veins *28*, *29*, *30* internal principal lateral vein.
Left: arteries *22*, *24*, *25* (collicular artery), *20*, *21*, *23* leaving this section for section X above (collicular artery), *1*, *2* (medial superior cerebellar artery); veins *31*; *32* internal principal lateral vein reaching the lateral mesencephalic vein)

III. Posterior group
Arteries: Green (collicular artery); Red (medial superior cerebellar artery *13* (VIII) reaching this section from section VII below: artery of the recess of the frenulum veli (superior cerebellar artery); veins *33* peripheral collicular veins (reaching the intercollicular vein), *15* (VIII), *16* (VIII) inferior central collicular veins leaving this section for section VIII below (vein of the recess of the frenulum veli, branches of the vein of the superior cerebellar peduncle)

Superficial vessels

ACA	Accessory collicular artery
AMCA	Accessory medial posterior choroidal artery
AMPV	Median anterior pontine vein
BV	Basal vein
CA	Collicular artery
ICV	Intercollicular vein
IPV	Interpeduncular vein
LMV	Lateral mesencephalic vein
MCA	Medial posterior choroidal artery
MSCA	Medial superior cerebellar artery
PCV	Precentral vein
VPM	Vein of the pontomesencephalic sulcus

Tracts and nuclei

CC	Crus cerebri
CTT	Central tegmental tract
IC	Inferior colliculus
IN	Interpeduncular nucleus
LL	Lateral lemniscus
ML	Medial lemniscus
MLF	Medial longitudinal fasciculus
MTT	Mesencephalic trigeminal tract
PGM	Periaqueductal grey matter
SCP	Superior cerebellar peduncle
SN	Substantia nigra
TN	Trochlear nucleus

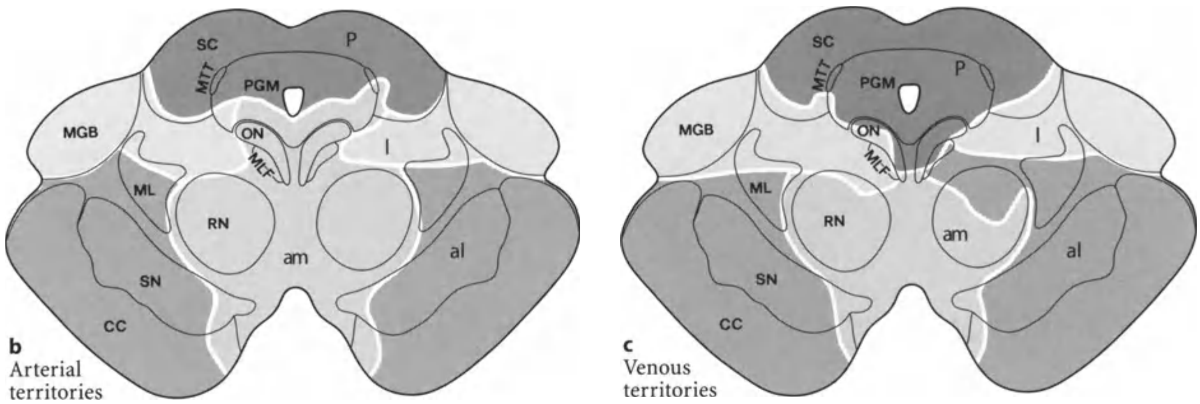


Fig. 33. (section X) Transverse Section of the Mesencephalon (at middle level). Internal Courses of the Arteries and Veins. The superficial arrangement of the arteries and veins can be followed on the anterior, posterior and lateral views of the brain stem (Figs. 20–23)

The inset drawings (**b** and **c**) delineate the territories vascularized by arteries and veins:

am: Territory of the anteromedial group
al: Territory of the anterolateral group
l: Territory of the lateral group
p: Territory of the posterior group

I. Anterior groups
A. Anteromedial group: arteries: arteries of the interpeduncular fossa (posterior cerebral arteries), *1* superior pedicle (thalamoperforating arteries), *2*, *2'* median rami of the intermediate pedicle (long and short arteries), *3* lateral rami of the intermediate pedicle, *1* belonging to the lateral rami of the interpeduncular fossa (collicular artery) (see p. 48); veins *1* median rami of the intermediate pedicle of the interpeduncular fossa, *2*, *3*, *4* lateral rami of the intermediate pedicle (these veins are branches of the interpeduncular veins)
B. Anterolateral group: Right: arteries (IX) *2*, *3*, *4*, *5* reaching this section from section IX below (collicular artery), *4*, *7* (posterior cerebral artery), *6* (anterior choroidal artery), *5* (medial posterior choroidal artery); veins (IX) *9*, *11*, *12*, *13* leaving this section for section IX below, *5*, *6*, *7*
Left: arteries (IX) *9*, *10*, *13*, *15* reaching this section from section IX below (collicular artery), *8* (posterior cerebral artery), *9* (anterior choroidal artery), *12*, *13* reaching this section from section IX below (medial posterior choroidal artery); veins *8*, *9*; (IX) *16*, *18*, *21*, *24*, *25* and *27* reaching this section from section IX below

II. Lateral group
Right: arteries (IX) *8* reaching this section from section IX below (collicular artery), *2*, *3* terminal branches of the accessory collicular artery (arteries of the superior collicular brachium), *11*, *10* (medial posterior choroidal artery); veins *10* principal internal lateral vein (see p. 54), *11*
Left: arteries *20*, *21*, *23* reaching this section from section IX below (collicular artery), *4* artery of the superior collicular brachium (collicular artery) *12*, *13* (medial posterior choroidal artery); veins *12*

III. Posterior group
Arteries: *green* (collicular arteries); *red* (medial superior cerebellar arteries); *blue* (medial posterior choroidal arteries). Veins *13* peripheral collicular veins, *14* middle central collicular vein (see p. 55), *15* superior central collicular vein (branches of superior median collicular vein)

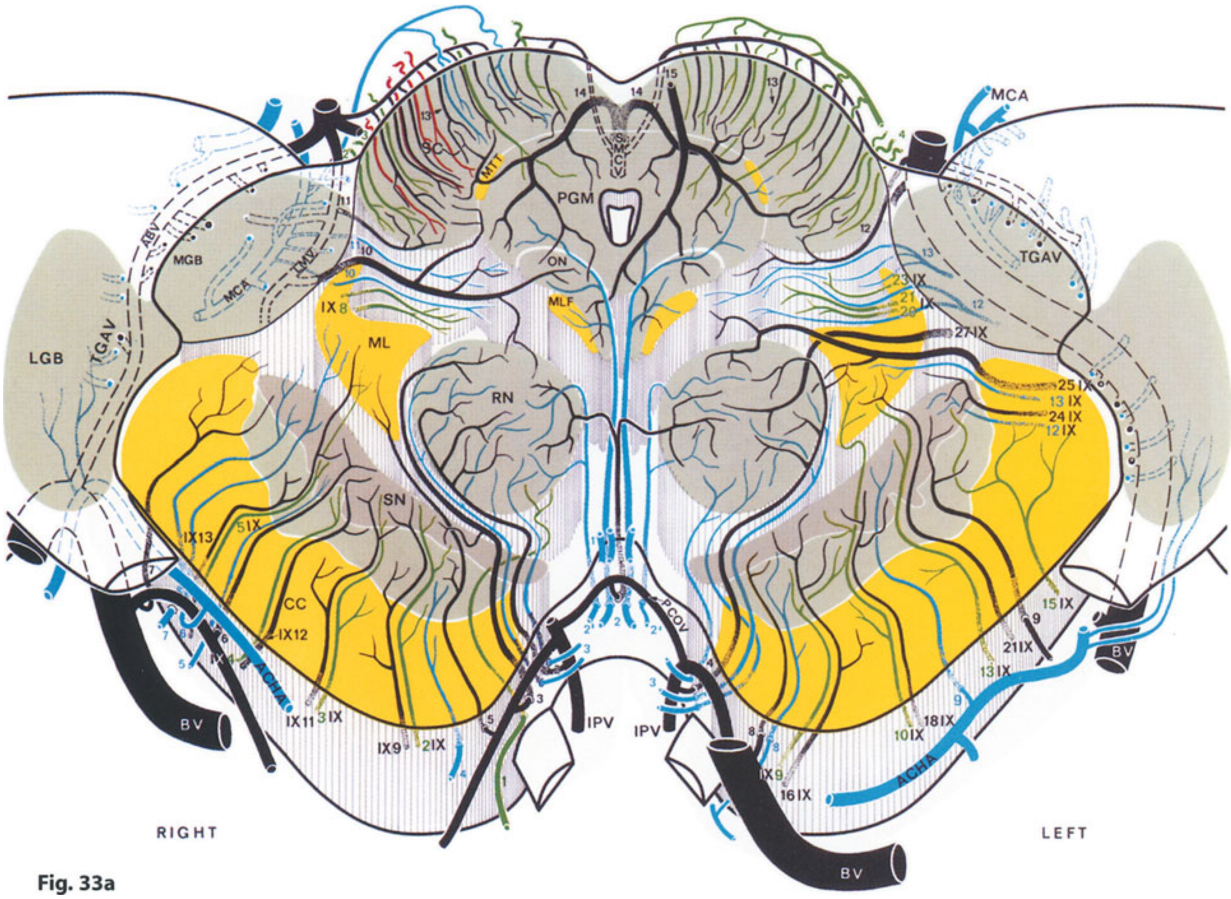


Fig. 33a

Superficial vessels

ABV	Accessory basal vein
ACHA	Anterior choroidal artery
BV	Basal vein
IPV	Interpeduncular veins
LMV	Lateral mesencephalic vein
MCA	Medial posterior choroidal artery
PCOV	Posterior communicating vein
SMCV	Superior median collicular vein
TGAV	Thalamogeniculate arteries and veins

Tracts and nuclei

CC	Crus cerebri
LGB	Lateral geniculate body
MGB	Medial geniculate body
ML	Medial lemniscus
MLF	Medial longitudinal fasciculus
MTT	Mesencephalic trigeminal tract
ON	Oculomotor nucleus
PGM	Periaqueductal grey matter
RN	Red nucleus
SC	Superior colliculus
SN	Substantia nigra

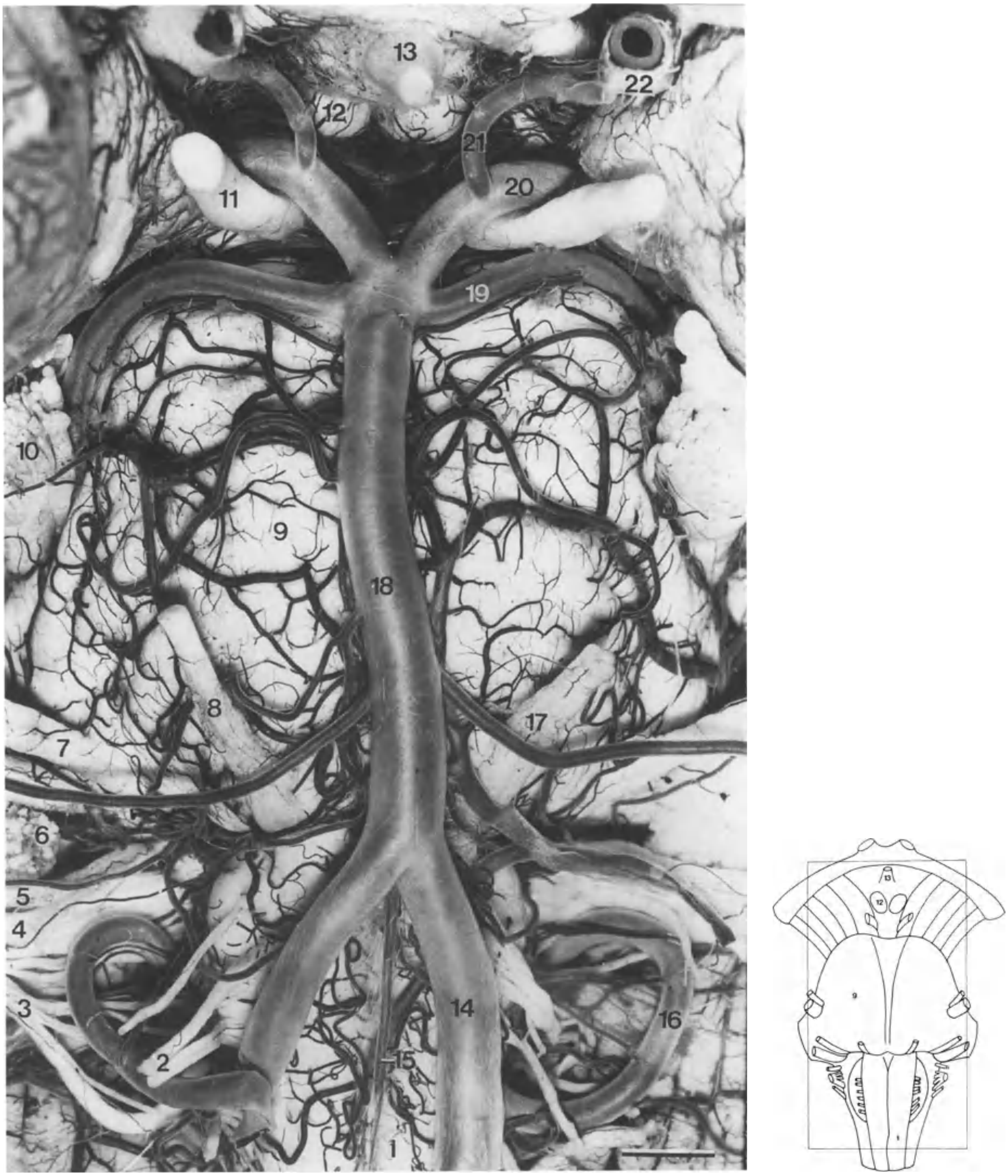


Fig. 34. Anterior View of the Brain Stem. **Bar, 4.6 mm**

1, Medulla; **2**, hypoglossal nerve; **3**, accessory nerve; **4**, vagus nerve; **5**, glossopharyngeal nerve; **6**, choroid plexus of the lateral recess of the fourth ventricle; **7**, facial nerve; **8**, abducent nerve; **9**, pons; **10**, trigeminal nerve; **11**, oculomotor nerve; **12**, mamillary body; **13**, hypophysial stalk; **14**, vertebral artery; **15**, anterior spinal artery; **16**, posterior inferior cerebellar artery; **17**, anterior inferior cerebellar artery; **18**, basilar artery; **19**, superior cerebellar artery; **20**, posterior cerebral artery; **21**, posterior communicating artery; **22**, internal carotid artery

Figures 35–51 show the superficial arteries and veins of the medulla.

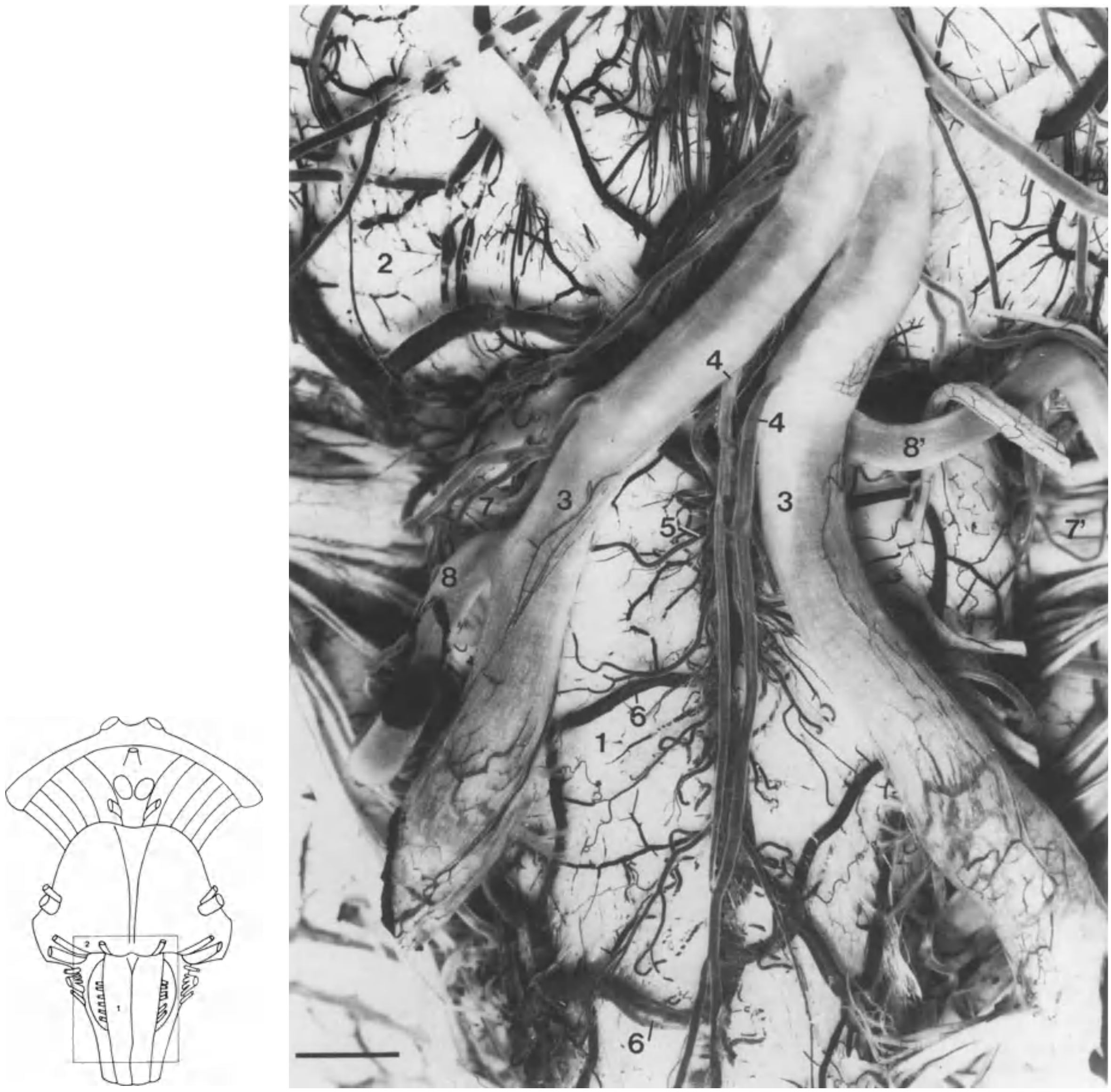


Fig. 35. General Aspect of the Arteries and Veins on an Anterior View of the Medulla. **Bar, 3.1 mm**

1, Anterior medullary surface (pyramid); **2**, pons; **3**, vertebral arteries; **4**, branches of origin of the anterior spinal artery; **5**, anteromedial group of medullary arteries; **6**, transverse medullary veins; **7** and **7'**, right and left lateral medullary fossae; **8** and **8'**, posterior inferior cerebellar arteries (note in this case their variable situation in relation to the lateral medullary fossa: inferior for the right and superior for the left) (see Figs. 39 and 42)

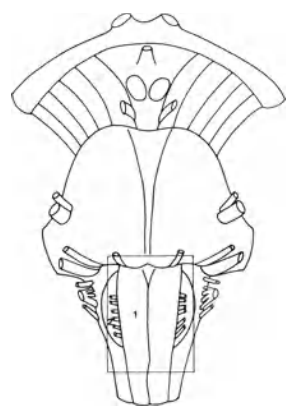


Fig. 36. Anterior Aspect of the Medulla. Bar, 2.5 mm

1, Pyramid of the medulla; **2**, inferior olive; **3**, hypoglossal nerve; **4**, vertebral arteries; **5**, anterior spinal artery; **6**, trunks of origin of the anterior spinal artery; **7**, median anterior medullary vein; **8**, transverse medullary vein; **9**, lateral anterior medullary (preolivary) vein; **10**, anteromedial group of medullary arteries (superior pedicle forming a dense arterial network); **10'**, anteromedial group of medullary arteries (inferior pedicle); **11**, anterolateral group of medullary arteries

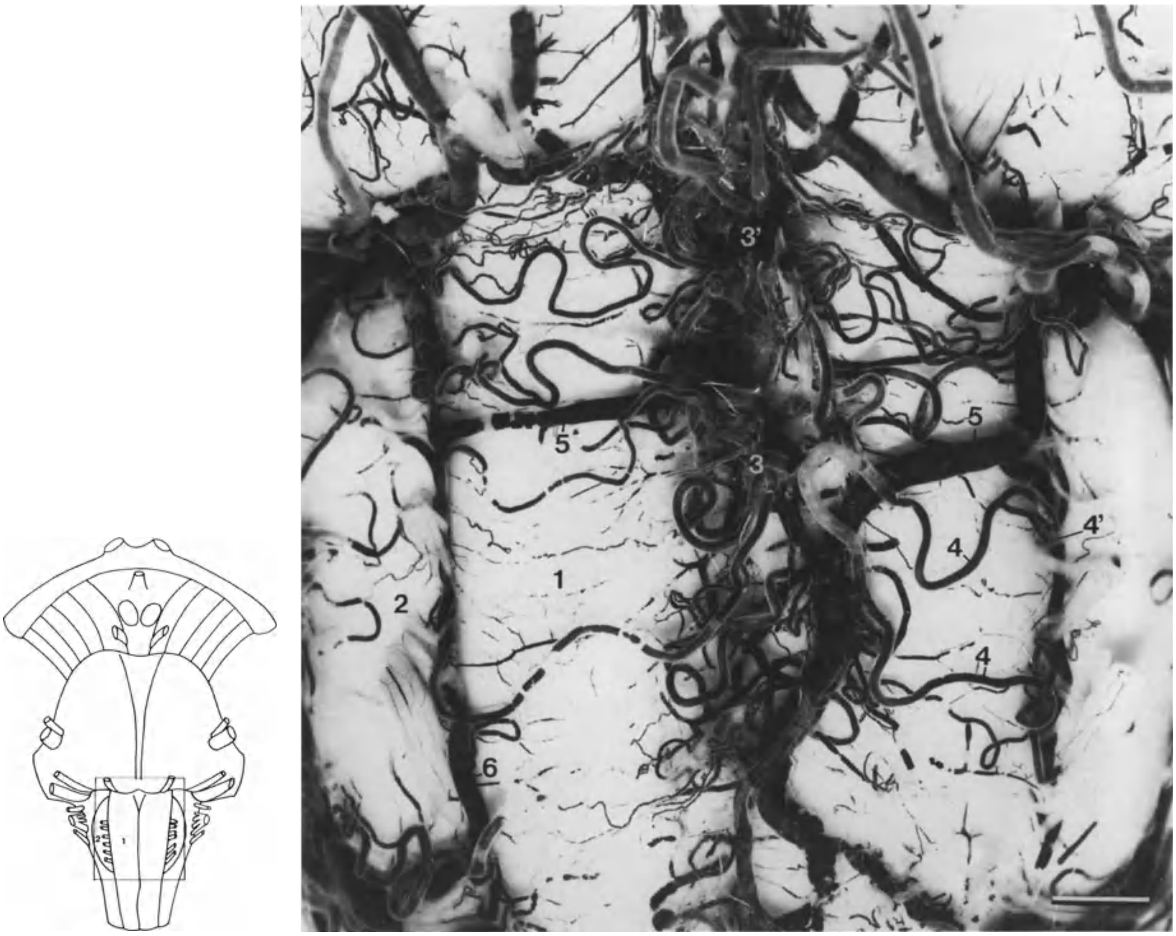


Fig. 37. Anterior Aspect of the Medulla. Bar, 1.8 mm

1, Pyramid; 2, inferior olive. The main arterial trunks have been removed to show the high arterial density of the anteromedial medullary group in the upper part of the antero median medullary sulcus (3) and in the foramen caecum (3'); 4, arteries of the anterolateral group reaching the preolivary sulcus (4'); 5, transverse medullary veins; 6, lateral anterior (preolivary) medullary vein

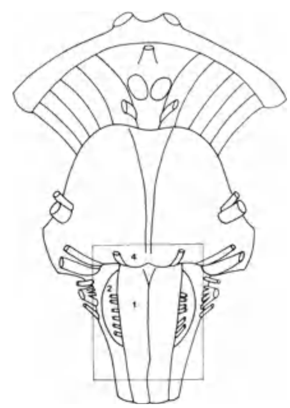


Fig. 38. Anterior Medullary Veins (after removal of the arterial network). **Bar, 4.5 mm**

1, Pyramid of the medulla; **2**, inferior olive; **3**, hypoglossal nerve; **4**, pons; **5**, median anterior medullary vein; **6**, lateral anterior (preolivary) medullary vein; **7**, transverse medullary veins; **7'**, in this case, a large transverse medullary vein drains the venous network through a venous trunk (**7"**) (bridging vein) which is a satellite of the hypoglossal nerve (*3*)

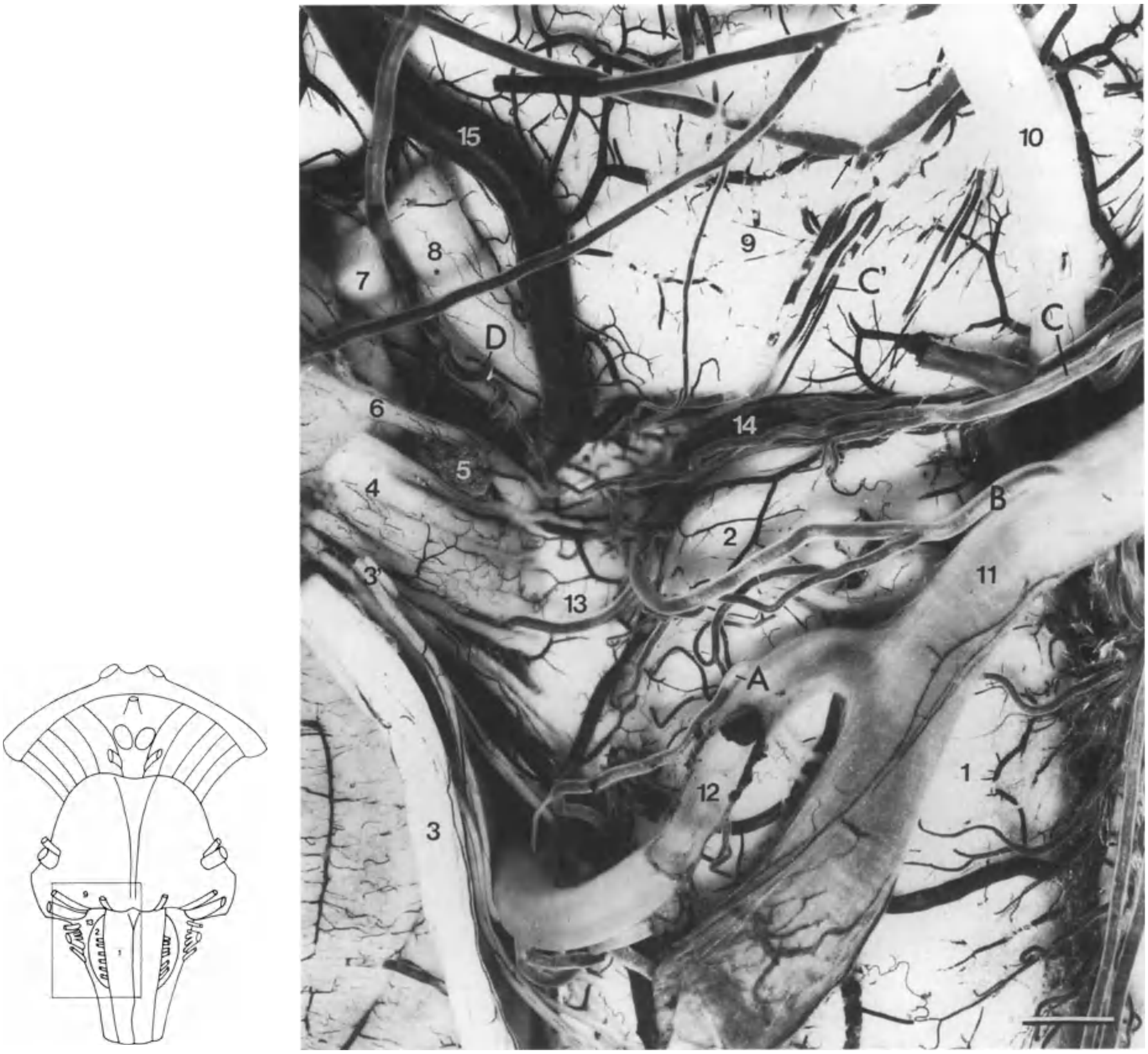


Fig. 39. Right Lateral Medullary Fossa. **Bar, 2.8 mm**

1, Pyramid of medulla; **2**, inferior olive; **3**, accessory nerve, spinal root; **3'**, accessory nerve, medullary root; **4**, vagus nerve; **5**, choroid plexuses and lateral aperture of fourth ventricle; **6**, glossopharyngeal nerve; **7**, vestibulocochlear nerve; **8**, facial nerve; **9**, pons, lateral surface; **10**, abducent nerve; **11**, vertebral artery; **12**, posterior inferior cerebellar artery; **13**, lateral medullary (retro-olivary) fossa. Arteries of the lateral medullary fossa (lateral group of medullary arteries): **A**, inferior rami originating from the posterior inferior cerebellar artery; **B**, middle rami arising from the vertebral artery; **C**, superior rami arising from the basilar artery; **C'**, superior rami arising from the anterior inferior cerebellar artery (*arrow*). These arteries enter the pontomedullary sulcus (14) and supply the pontine tegmentum (see Figs. 27 and 28); **D**, posterior rami originating from the anterior inferior cerebellar artery; **15**, lateral pontine vein

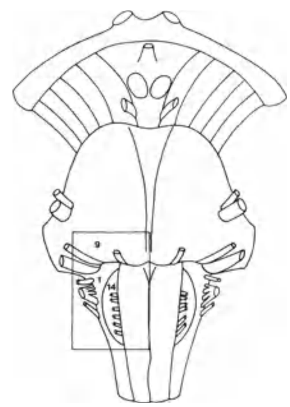


Fig. 40. Right Lateral Medullary Fossa. Same preparation as that used for Fig. 39 after removal of the larger arterial trunks. **Bar, 3.3 mm**

1, Lateral medullary (retro-olivary) fossa; **2**, accessory nerve (medullary root); **2′**, accessory nerve (spinal root); **3**, vagus nerve; **4**, glossopharyngeal nerve; **5**, lateral aperture of the fourth ventricle; **6**, vestibulocochlear nerve; **7**, facial nerve; **8**, lateral pontine vein; **9**, pons; **10**, abducent nerve; **11**, transverse medullary vein; **12**, lateral medullary vein draining into the lateral pontine vein (*8*); **13**, posterior inferior cerebellar artery; **14**, inferior olive; **15**, retro-olivary vein;

A, inferior rami of the lateral medullary fossa (posterior inferior cerebellar artery); **B**, middle rami of the lateral medullary fossa (vertebral artery); **C**, superior rami of the lateral medullary fossa (basilar artery); **C′**, superior rami of the lateral medullary fossa (anterior inferior cerebellar artery); **D**, posterior rami of the lateral medullary fossa (anterior inferior cerebellar artery)

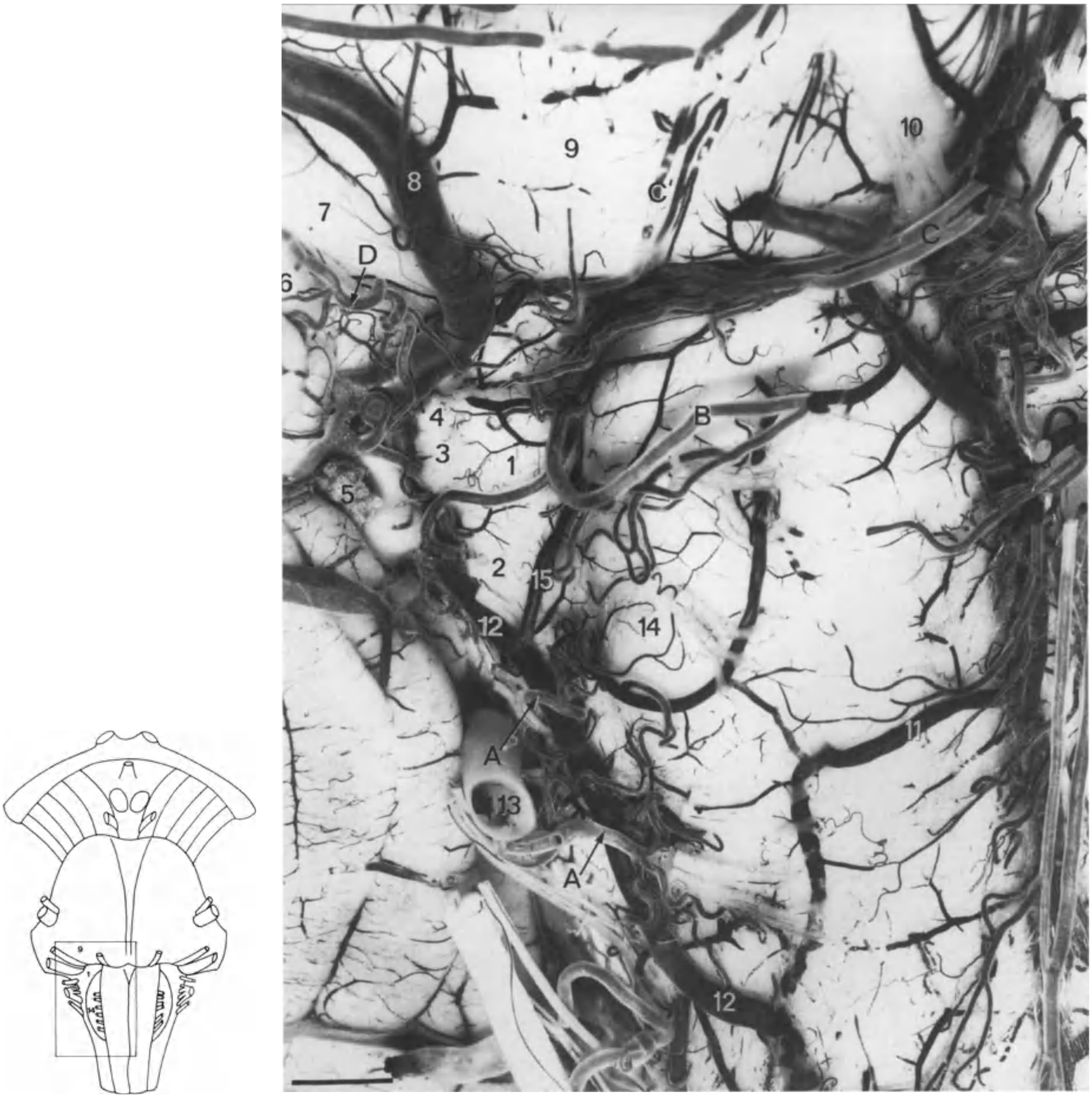


Fig. 41. Right Lateral Medullary Fossa. Same preparation as that used for Fig. 40 after removal of the larger arterial trunks and section of the glossopharyngeal, vagus and accessory nerves. Bar, 3.2 mm

1, Lateral medullary fossa; **2**, accessory nerve; **3**, vagus nerve; **4**, glossopharyngeal nerve; **5**, lateral aperture of the fourth ventricle; **6**, vestibulocochlear nerve; **7**, facial nerve; **8**, lateral pontine vein; **9**, pons; **10**, abducent nerve; **11**, transverse medullary vein; **12**, lateral medullary vein draining into the lateral pontine vein (*8*) (note its course hidden by the roots of the nerves); **13**, posterior inferior cerebellar artery; **14**, inferior olive; **15**, retro-olivary vein; **A**, inferior rami of the lateral medullary fossa (posterior inferior cerebellar artery); **B**, middle rami of the lateral medullary fossa (vertebral artery); **C**, superior rami of the lateral medullary fossa (basilar artery); **C'**, superior rami of the lateral medullary fossa (anterior inferior cerebellar artery); **D**, posterior rami of the lateral medullary fossa (anterior inferior cerebellar artery)

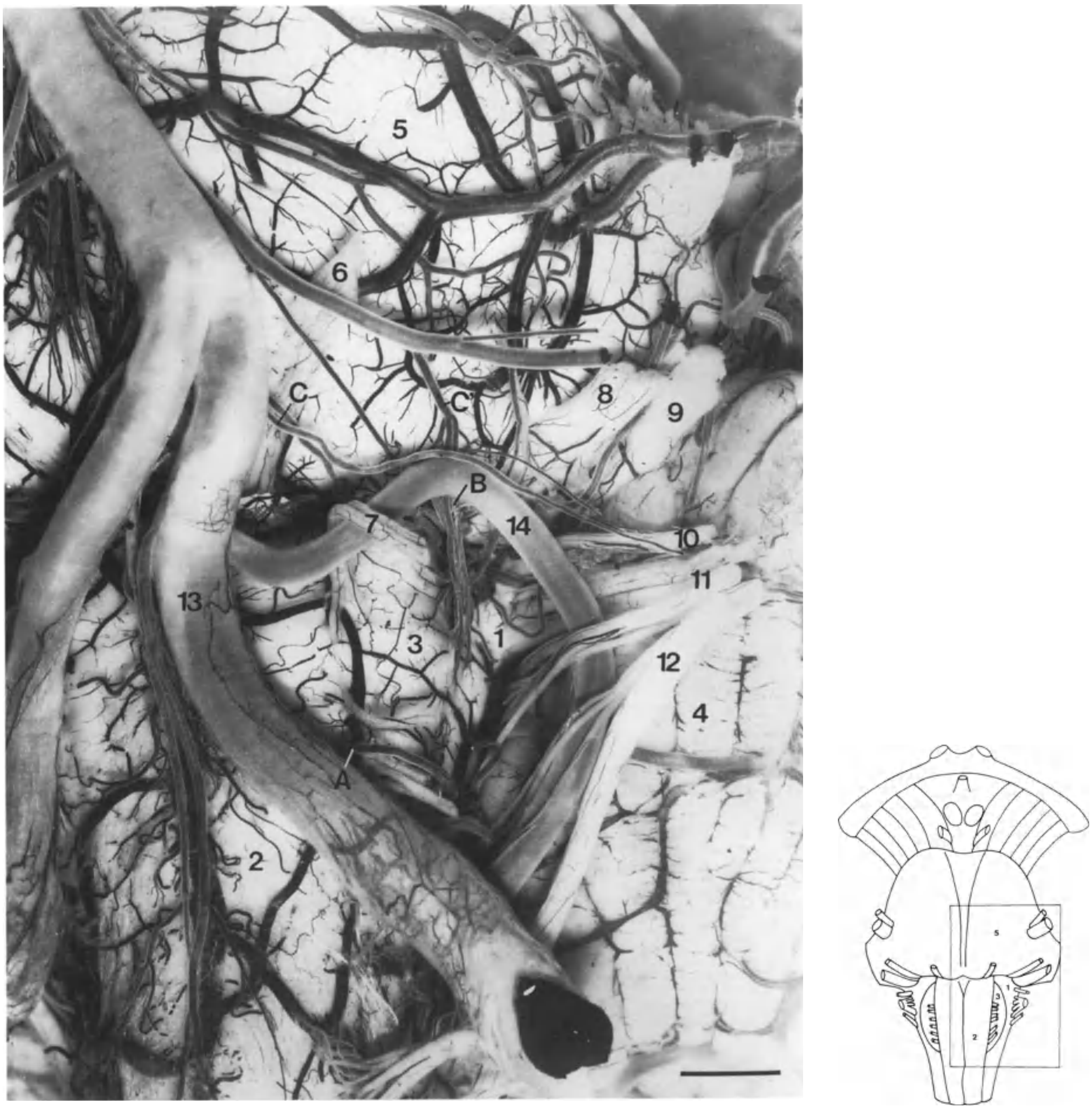


Fig. 42. Left Lateral Medullary Fossa. **Bar, 3.7 mm**

1, Left lateral medullary fossa; **2**, pyramid; **3**, inferior olive; **4**, cerebellum; **5**, pons; **6**, abducent nerve; **7**, hypoglossal nerve; **8**, facial nerve; **9**, vestibulocochlear nerve; **10**, glossopharyngeal nerve; **11**, vagus nerve ; **12**, accessory nerve (spinal root); **13**, left vertebral artery; **14**, the situation of the left posterior inferior cerebellar artery which is, in this case, above the lateral medullary fossa, induces modifications concerning the origin of the arterial rami of the lateral medullary fossa: **A**, inferior rami arising from the vertebral artery; **B**, middle rami arising from the posterior inferior cerebellar artery; **C** and **C'**, superior rami arising from the vertebral and anterior inferior cerebellar arteries

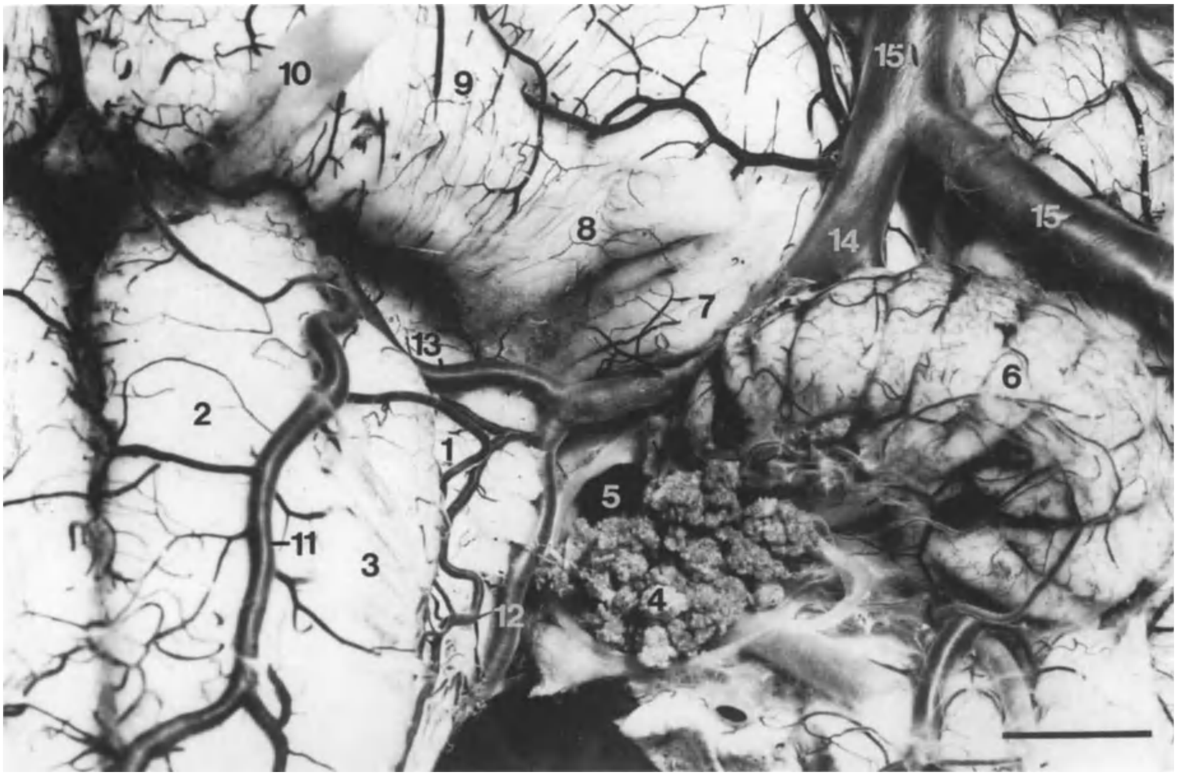
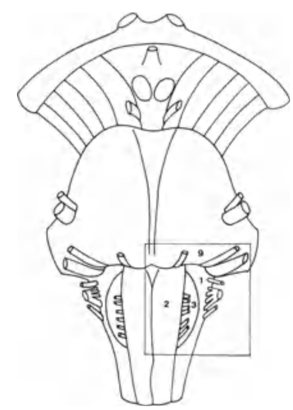


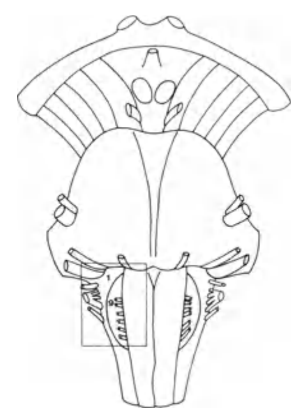
Fig. 43. Left Lateral Medullary Fossa. Venous Network After Removal of the Overlapping Arterial Network. **Bar, 4 mm**



1, Lateral medullary fossa; **2**, pyramid of medulla; **3**, inferior olive; **4**, extraventricular choroid plexus; **5**, lateral aperture of the fourth ventricle; **6**, flocculus; **7**, vestibulocochlear nerve; **8**, facial nerve; **9**, pons; **10**, abducent nerve; **11**, lateral anterior medullary vein

The lateral medullary vein (**12**) together with the vein of the pontomedullary sulcus (**13**) reaches the lateral pontine vein (**14**) which is a tributary of the anterior cerebellar vein (**15**)

Fig. 44. Right Lateral Medullary Fossa. **Bar, 2.8 mm**



1, Lateral medullary fossa; **2**, choroid plexuses of the fourth ventricle; **3**, toenia of the lateral aperture (**4**) of the fourth ventricle (anterior ligula, see Fig. 7); **5**, the lateral medullary vein, large in this case, is drained toward the sigmoid sinus (bridging vein) (*arrow*); **6**, glossopharyngeal nerve; **7**, vagus nerve; **8**, accessory nerve (medullary root); **8'**, accessory nerve (spinal root); **9**, inferior olive

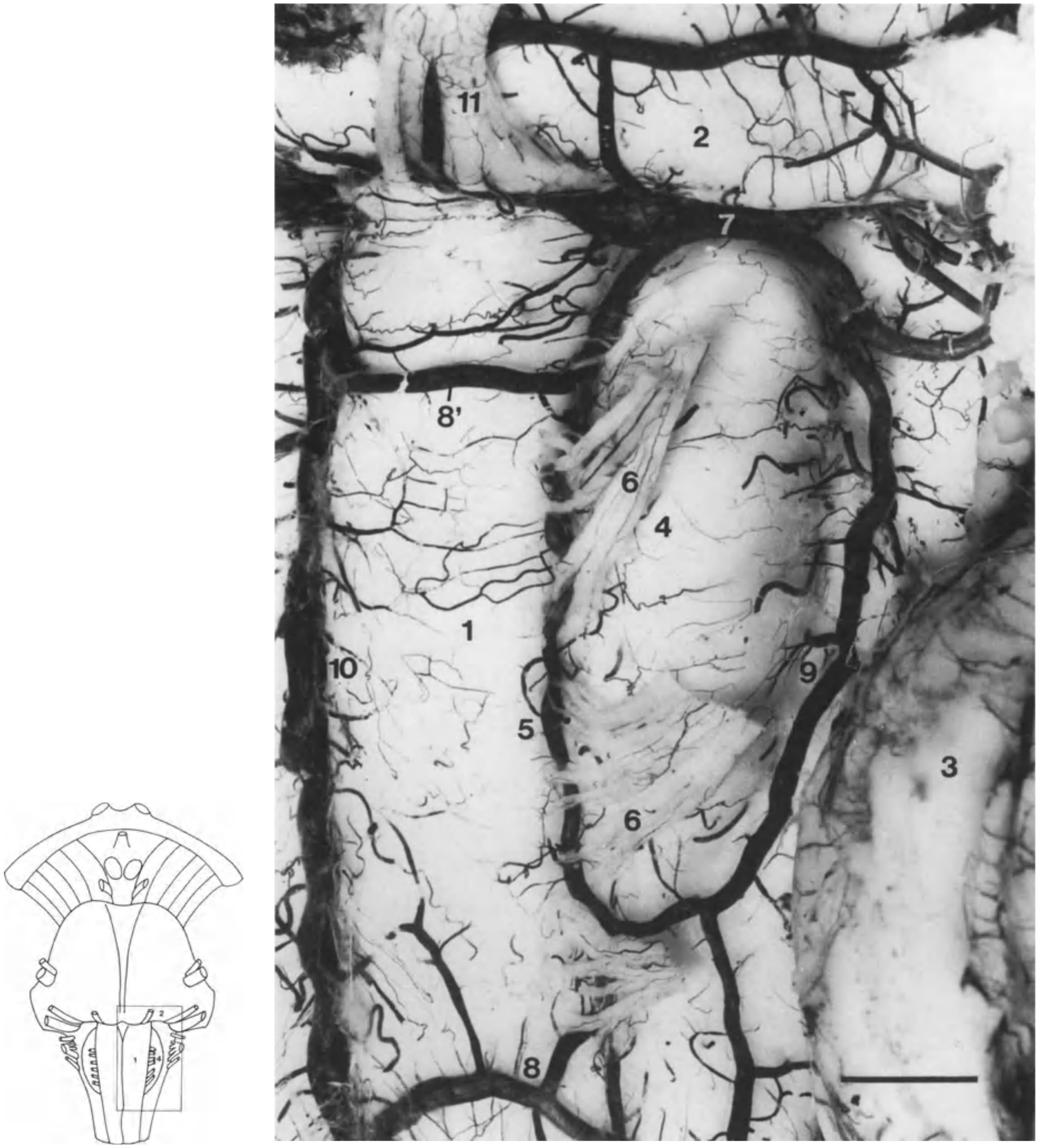
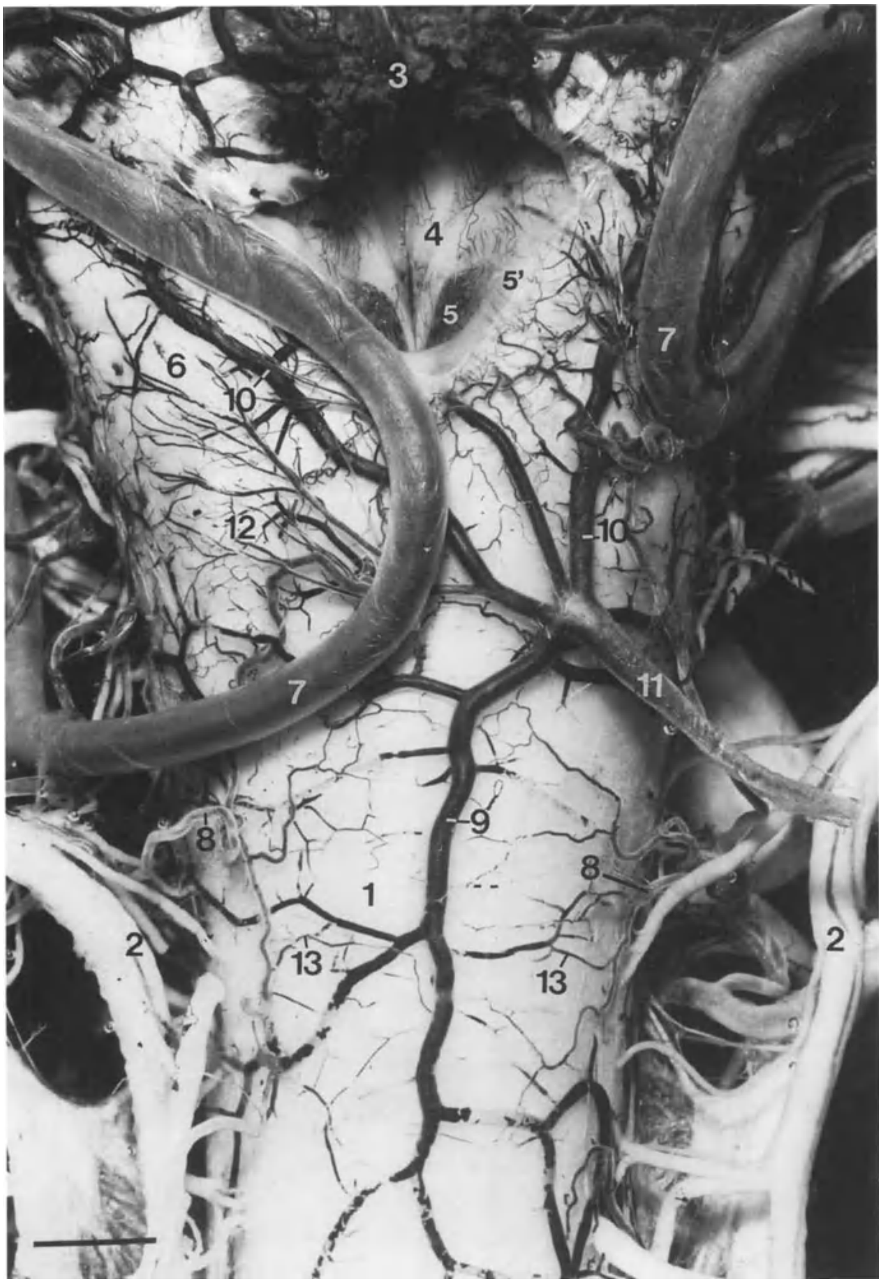


Fig. 45. Anterior View of the Medulla (after removal of the arterial network, left side). **Bar, 2.6 mm**

1, Pyramid; **2**, pons; **3**, cerebellum. The venous circle around the inferior olive (**4**) is made up of the lateral anterior medullary (preolivary) vein (**5**) partially hidden by the emergence of the hypoglossal nerve (**6**), of the vein of the pontomedullary sulcus (**7**), of the inferior transverse medullary vein (**8**) (**8'** superior transverse medullary vein) and of the retro-olivary vein (**9**) (see p. 34). **10**, median anterior medullary vein; **11**, abducent nerve



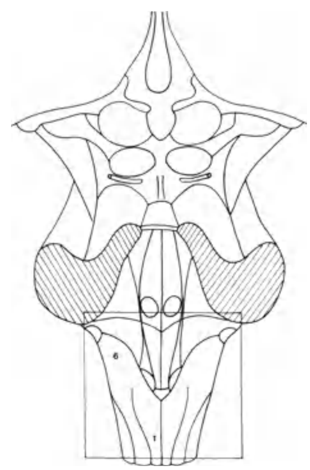
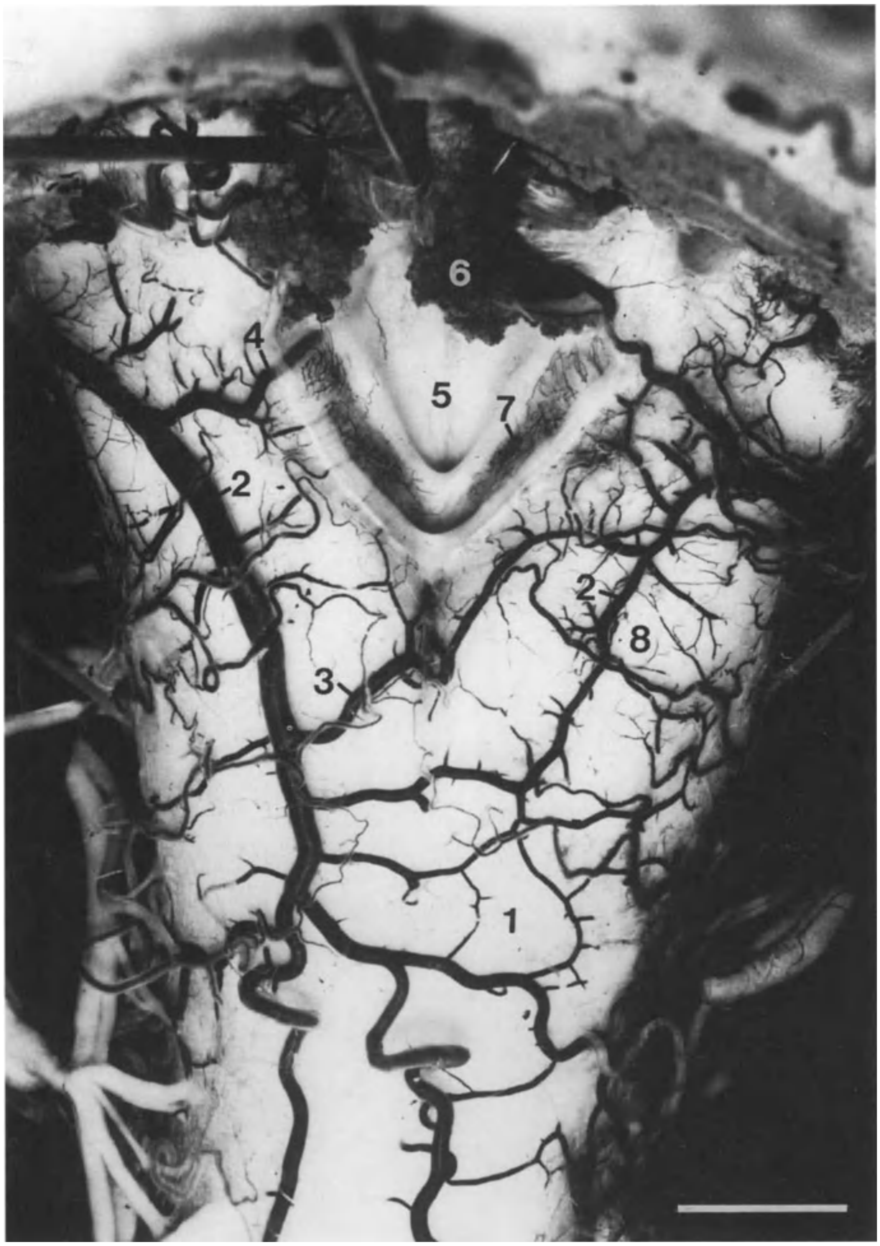


Fig. 46. Posterior View of the Medulla (after removal of the cerebellum). Bar, 3.3 mm

1, Medulla, posterior aspect; **2**, accessory nerve, spinal root; **3**, choroid plexuses of the fourth ventricle (displaced upward); **4**, median aperture of the fourth ventricle (foramen of Magendie); **5**, area postrema (5′ ligula); **6**, inferior cerebellar peduncle (restiform body); **7**, posterior inferior cerebellar arteries; **8**, posterior spinal arteries; **9**, median posterior medullary vein; **10**, marginal veins of the floor of the fourth ventricle; **11**, in this specimen, the posterior venous network is drained towards the marginal sinus bordering the foramen magnum, by a bridging vein which crosses the cerebellomedullary cistern (vein of the cerebellomedullary cistern); **12**, posterior group of medullary arteries arising from the posterior inferior cerebellar arteries; **13**, posterior group of medullary arteries arising from the posterior spinal arteries (for more information about the vascularization of the posterior medullary surface see LASJAUNIAS et al. 1985 and MAILLOT and KORITKE 1970)

Fig. 47. Posterior View of the Medulla (1) (after removal of cerebellum and of the arterial network). **Bar, 3 mm**

The venous network of the posterior surface of the medulla, is composed of a median posterior medullary vein (2) dividing into two right and left marginal veins (3) of the ventricular floor (4). These veins flow into the lateral medullary veins (see Fig. 18). This typical and symmetrical aspect is rare (see following figures). 5, inferior cerebellar peduncle (restiform body)



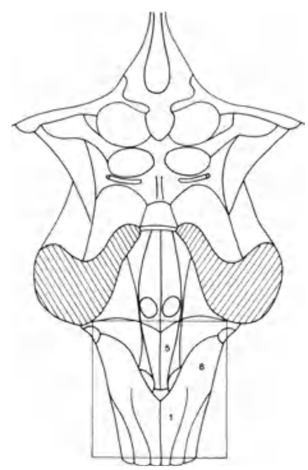


Fig. 48. Posterior View of the Medulla (1) (after removal of the cerebellum and of the arterial network). **Bar, 3.3 mm**

In this case, the median posterior medullary vein is absent and the marginal veins of the ventricular floor (2) (here at some distance from the ventricle and often called veins of the inferior cerebellar peduncles) have an asymmetrical aspect: the left is dominant. It receives an internal median posterior vein (vein of the obex, 3) and an internal lateral posterior vein (subependymal vein of the ventricular floor) (4). 5, Floor of the fourth ventricle; 6, the choroid plexuses have been displaced upward; 7, area postrema; 8, inferior cerebellar peduncle

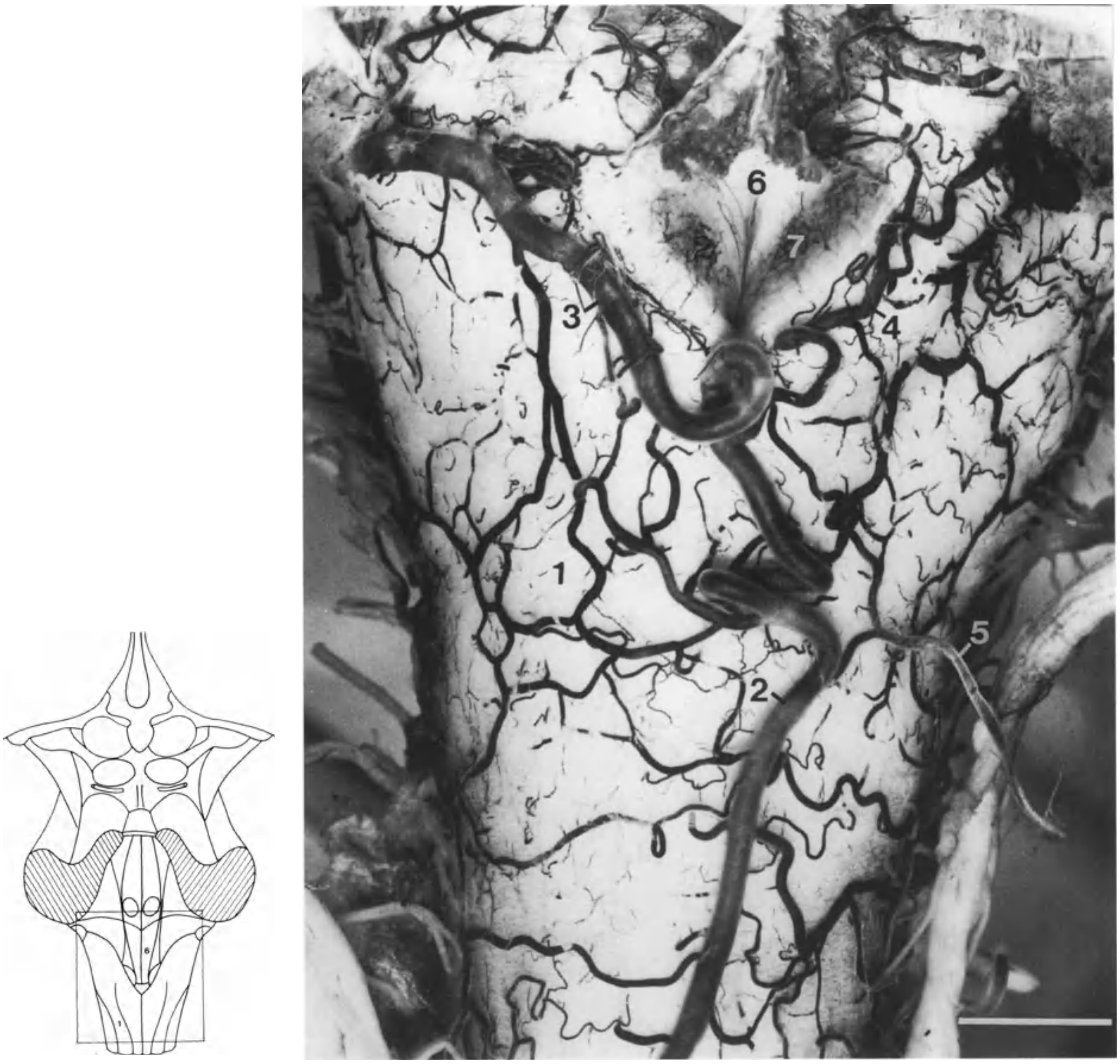


Fig. 49. Posterior View of the Medulla (1) (after removal of the cerebellum and the arterial network). **Bar, 4 mm**

The median posterior medullary vein (2) drained by a dominant left marginal vein of the ventricular floor (3), displays a tortuous aspect. In this case the right marginal vein (4) is small. Note an accessory drainage (5) towards the marginal sinus (see Fig. 50). **6**, Ventricular floor; **7**, Area postrema

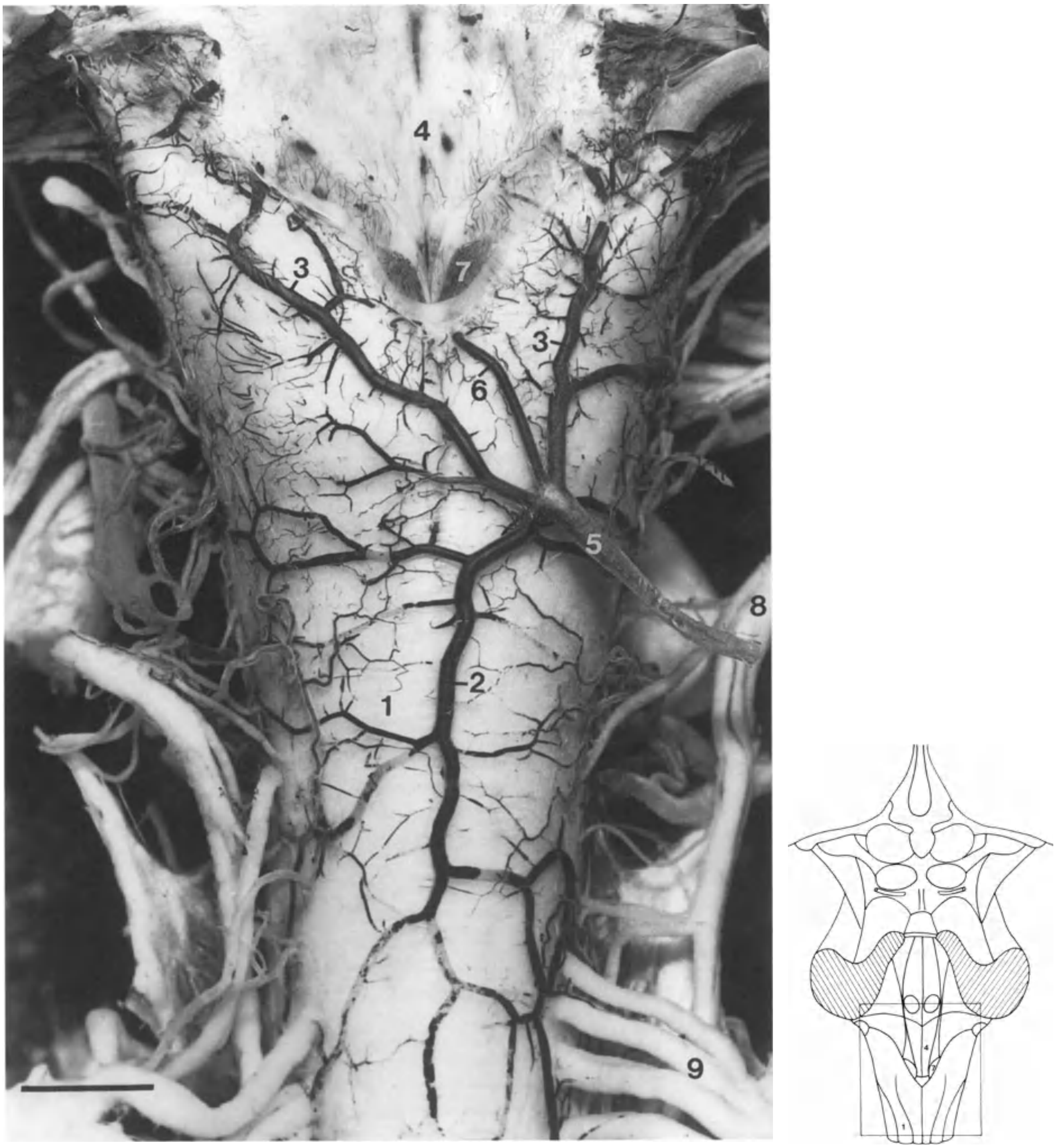


Fig. 50. Posterior View of the Medulla (1) (after removal of the cerebellum and of the arterial network) (see Fig. 46)
Bar, 4.4 mm

In this specimen, the venous network of the posterior medullary surface, formed by the median posterior medullary vein (2) and the marginal veins (3) of the ventricular floor (4), is drained by a bridging vein (5) (vein of the cerebellomedullary cistern) towards the marginal sinus bordering the foramen magnum (or toward the occipital sinus). **6**, Internal median posterior medullary vein (vein of the obex); **7**, area postrema; **8**, spinal root of accessory nerve; **9**, dorsal roots of second cervical nerve

Fig. 51. Posterior View of the Medulla (the cerebellum, 1, has been left intact). Bar, 4.4 mm

The median posterior medullary vein (2) is drained by a large bridging vein crossing the cerebellomedullary cistern (vein of the cerebellomedullary cistern, 3) toward the marginal sinus bordering the foramen magnum. An *arrow* shows the point where this vein opens into the marginal sinus through the arachnoid (4). 5, Posterior inferior cerebellar artery

Figures 52–61 show the superficial arteries and veins of the pons.

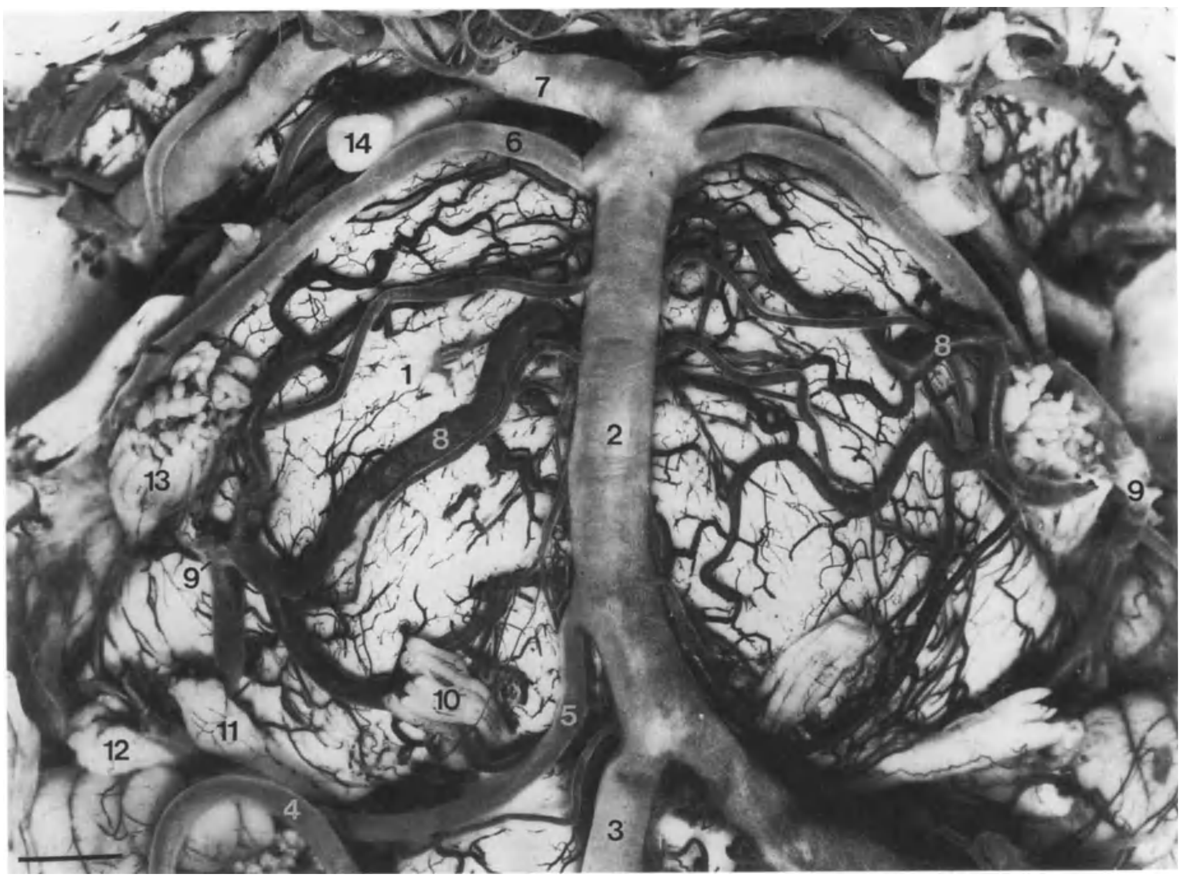
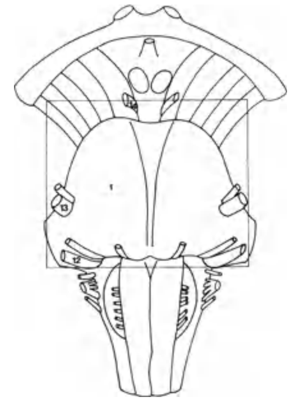


Fig. 52. Anterior View of the Pons (1). **Bar, 3.7 mm**



Arteries of the anterior pontine surface: **2**, basilar artery; **3**, vertebral artery; **4**, posterior inferior cerebellar artery; **5**, anterior inferior cerebellar artery; **6**, superior cerebellar artery; **7**, posterior cerebral artery. Veins of the anterior pontine surface: **8**, the transverse pontine veins are drained into the superior petrosal veins (**9**); **10**, abducent nerve; **11**, facial nerve; **12**, vestibulocochlear nerve; **13**, trigeminal nerve (note the density of veins and arteries around the root of the nerve); **14**, oculomotor nerve

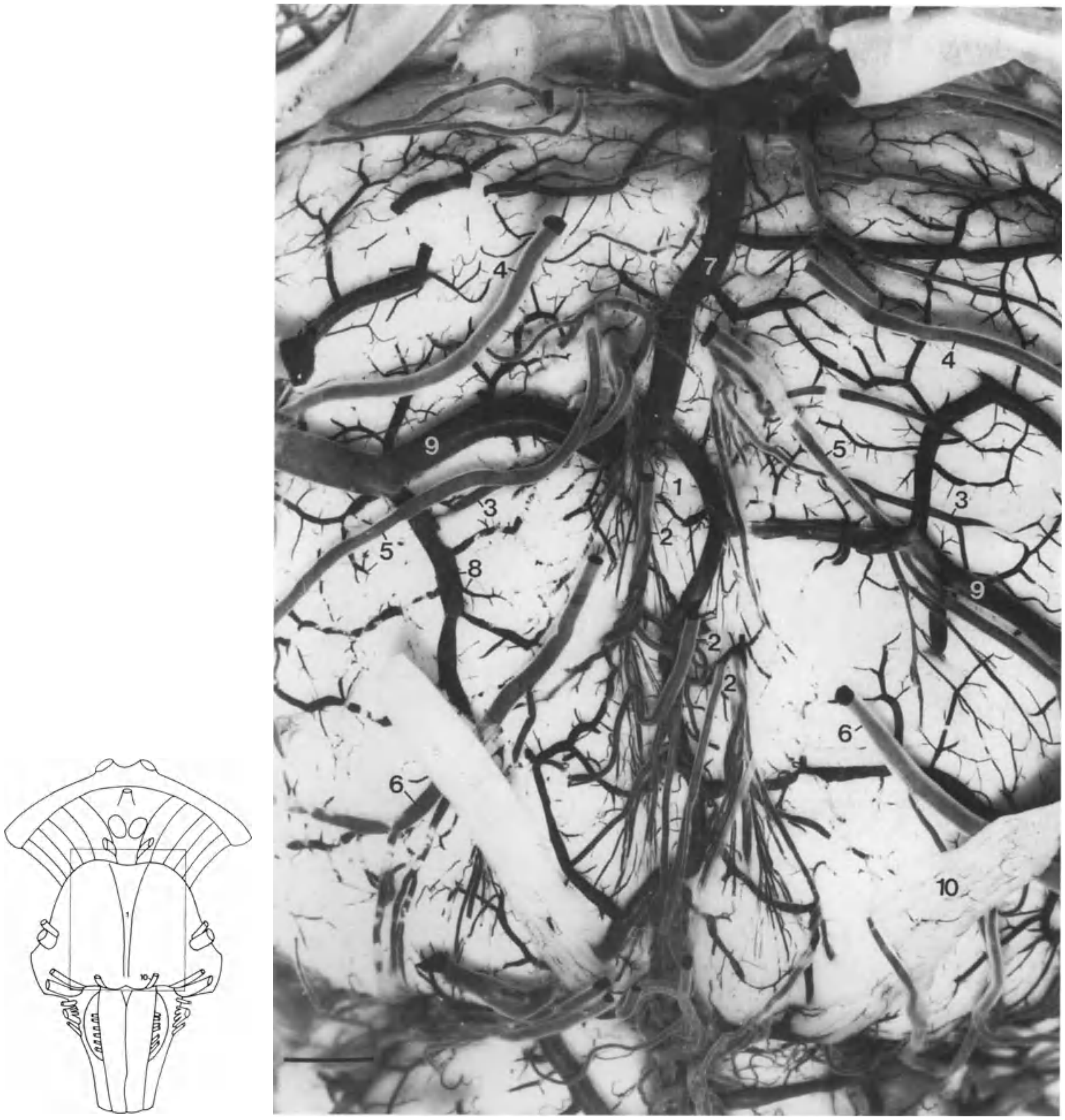
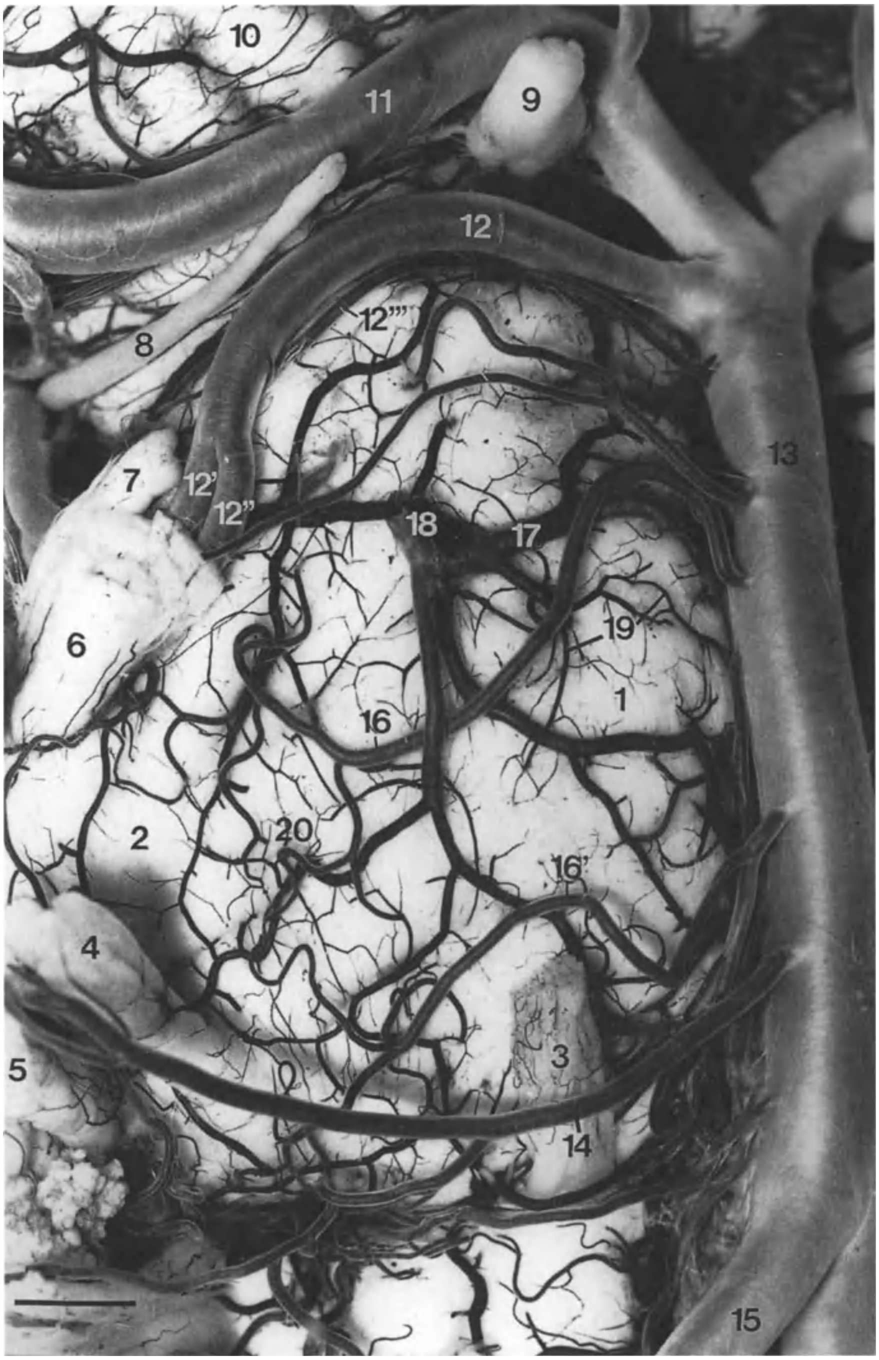


Fig. 53. Anterior View of the Pons. Bar, 3.1 mm

1, Basilar sulcus; 2, anteromedial group of pontine arteries; 3, anterolateral group of pontine arteries; 4, superior lateral pontine arteries; 5, inferior lateral pontine arteries; 6, anterior inferior cerebellar arteries; 7, median anterior pontine vein; 8, lateral anterior pontine vein; 9, transverse pontine veins; 10, abducent nerve



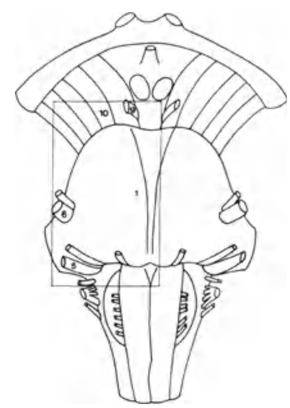


Fig. 54. Right Lateral View of the Pons. **Bar, 4 mm**

1, Ventral part of the pons; **2**, lateral pontine surface (anterior area, *AA*, see p. 40); **3**, abducent nerve; **4**, facial nerve; **5**, vestibulocochlear nerve; **6**, trigeminal nerve, sensory root; **7**, trigeminal nerve, motor root; **8**, trochlear nerve; **9**, oculomotor nerve; **10**, anterior mesencephalic surface (crus cerebri); **11**, posterior cerebral artery; **12**, superior cerebellar artery; **12′**, **12″**, medial and lateral branch of superior cerebellar artery; **12‴**, posterolateral pontine artery; **13**, basilar artery; **14**, anterior inferior cerebellar artery; **15**, vertebral artery; **16**, superior and inferior (**16′**) lateral pontine arteries; **17**, transverse pontine vein, and **18**, its drainage towards the basilar plexus; **19**, anterolateral group of pontine blood vessels; **20**, lateral group of pontine blood vessels

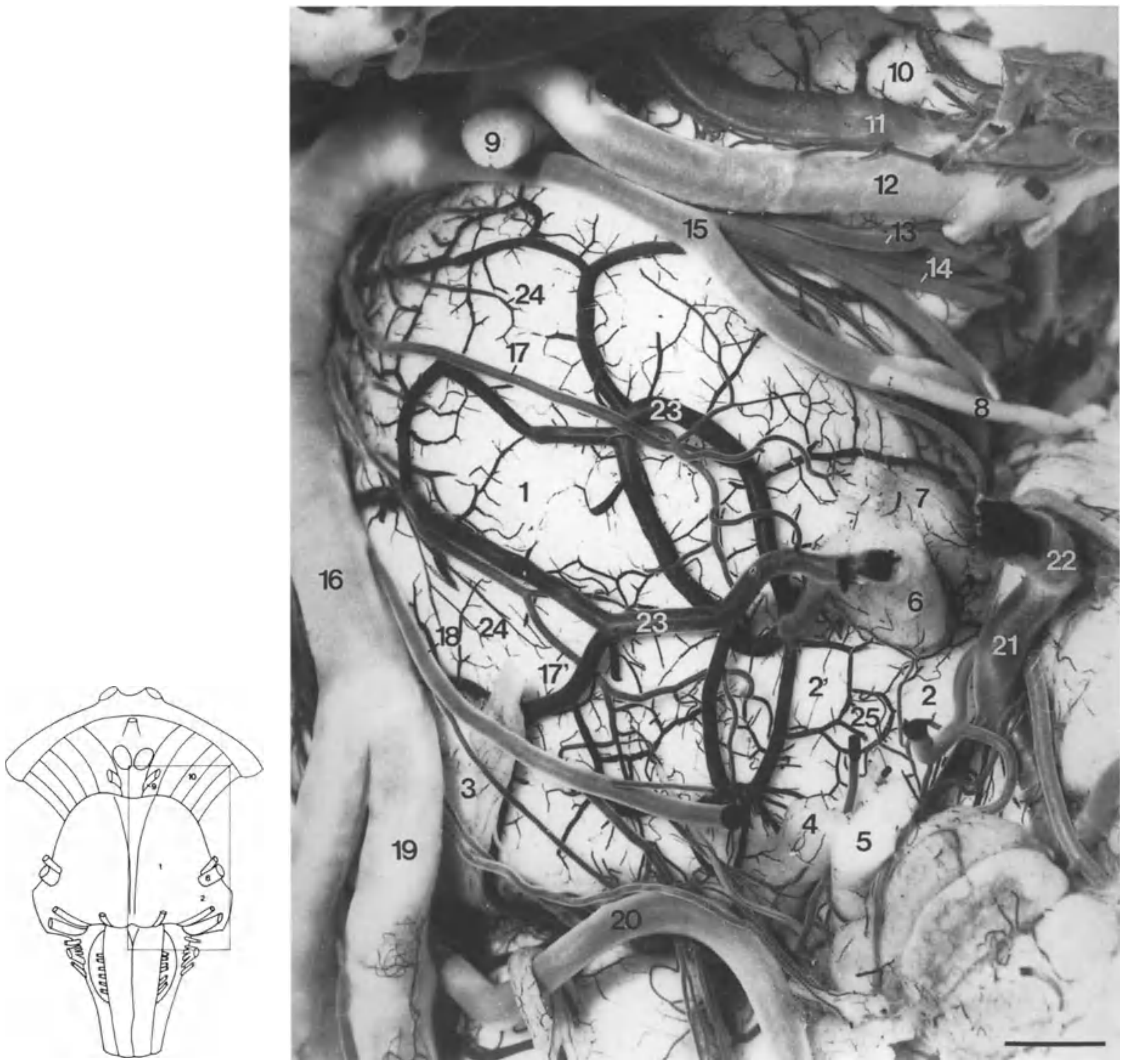
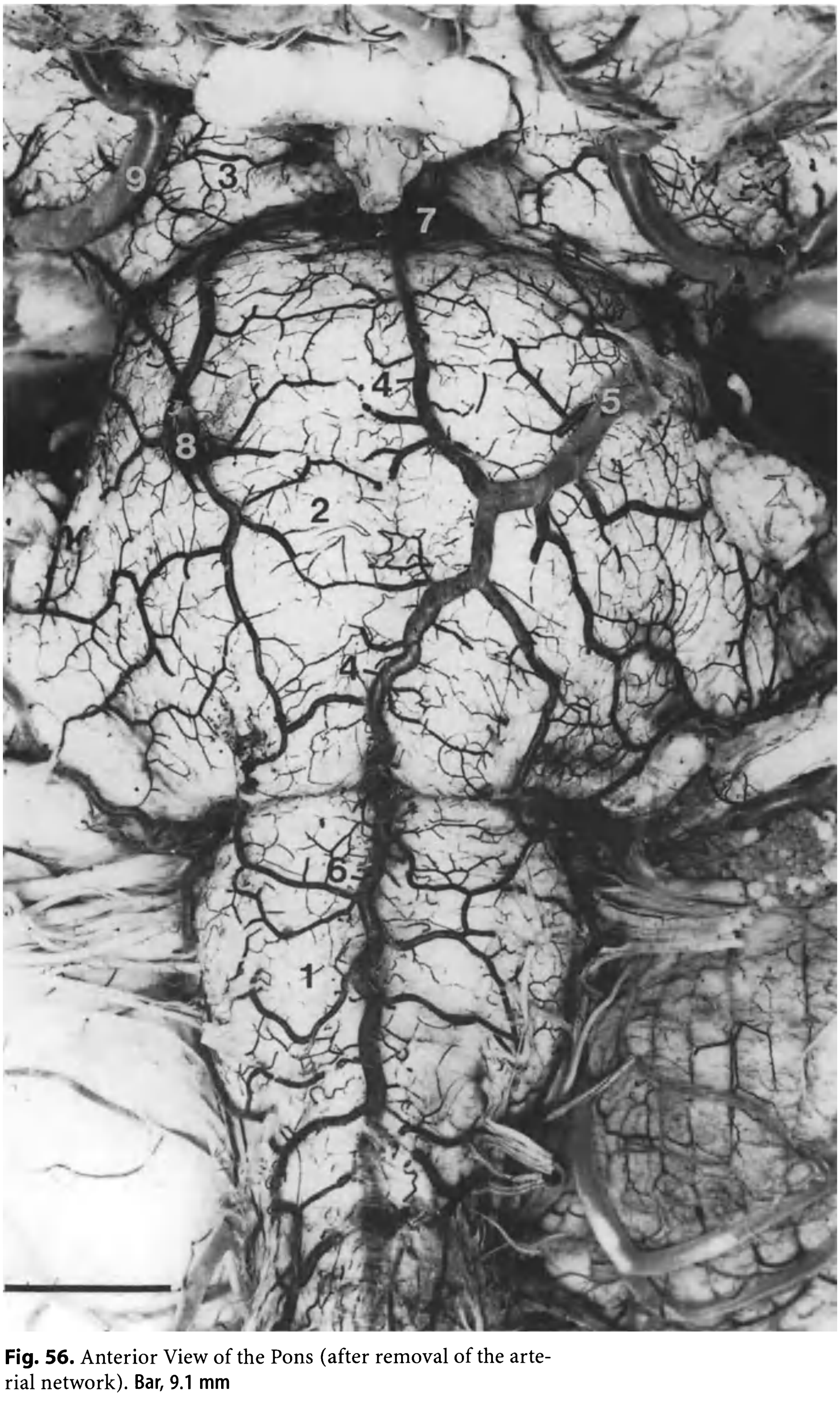


Fig. 55. Left Lateral View of the Pons. Bar, 4.6 mm

1, Ventral part of the pons; **2**, lateral pontine surface (inferior area, *IA*, see p. 40); **2'**, lateral pontine surface (anterior area *AA* see p. 40); **3**, abducent nerve; **4**, facial nerve; **5**, vestibulocochlear nerve; **6**, trigeminal nerve, sensory root; **7**, trigeminal nerve, motor root; **8**, trochlear nerve; **9**, oculomotor nerve; **10**, anterior surface of the mesencephalon (crus cerebri); **11**, basal vein, ventral segment; **12**, posterior cerebral artery; **13**, medial posterior choroidal artery; **14**, collicular artery; **15**, superior cerebellar artery; **16**, basilar artery; **17**, **17'**, superior and inferior lateral pontine arteries; **18**, anterior inferior cerebellar artery; **19**, vertebral artery; **20**, posterior inferior cerebellar artery; **21**, anterior cerebellar vein; **22**, superior petrosal vein; **23**, transverse pontine veins; **24**, anterolateral group of pontine blood vessels; **25**, lateral group of pontine blood vessels



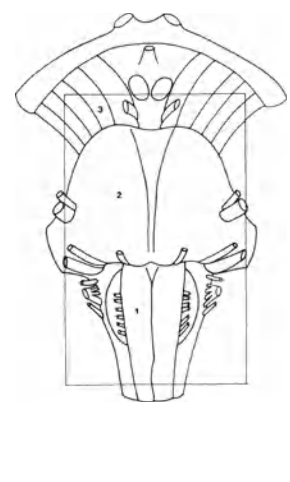


Fig. 56. Anterior View of the Pons (after removal of the arterial network). **Bar, 9.1 mm**

1, Medulla; **2**, pons; **3**, crus cerebri. The median anterior pontine vein (**4**) is drained toward the basilar plexus (**5**). The median anterior pontine vein is linked to the median anterior medullary vein (**6**) and, in the interpeduncular fossa (**7**), to the interpeduncular veins (see Fig. 72); **8**, accessory drainage of the right venous network of the pons into the basilar plexus; **9**, basal vein

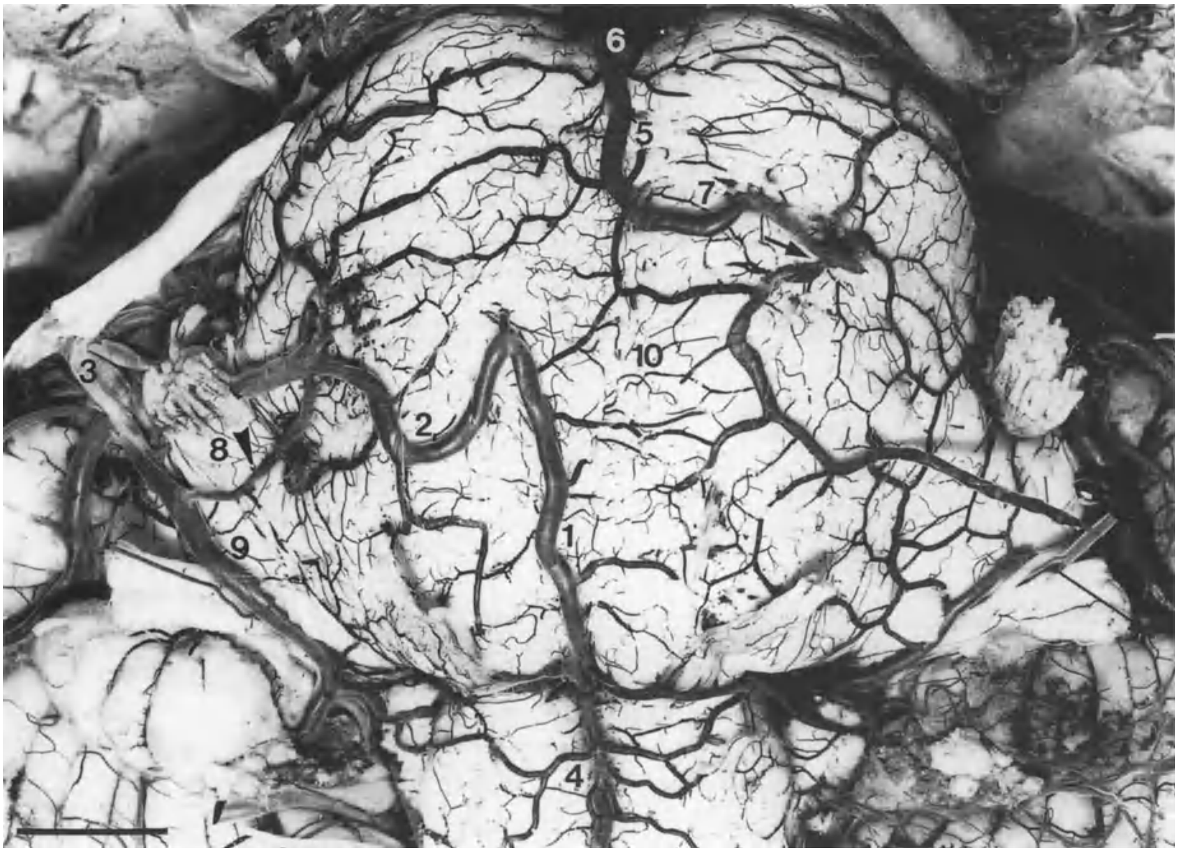
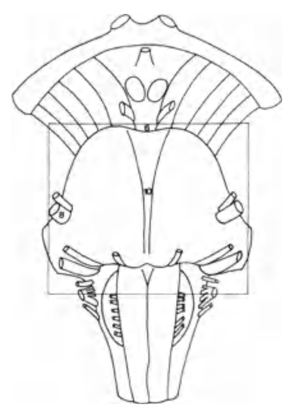


Fig. 57. Anterior View of the Pons (after removal of the arterial network). **Bar, 6.6 mm**



The median anterior pontine vein is here discontinuous (see p. 39): **1**, Inferior segment of the median anterior pontine vein, draining through a right transverse pontine vein (**2**) into the superior petrosal vein (**3**). **4**, Median anterior medullary vein; **5**, superior segment of the median anterior pontine vein (pontomesencephalic vein) (**6** interpeduncular fossa). The superior segment of the median anterior pontine vein is drained (**7**) into the basilar plexus (*arrow*). **8**, Trigeminal nerve which is surrounded by a venous circle (*arrow*, see p. 40); **9**, lateral pontine vein; **10**, basilar sulcus and the emergence of the anteromedial group of pontine veins (see p. 39)

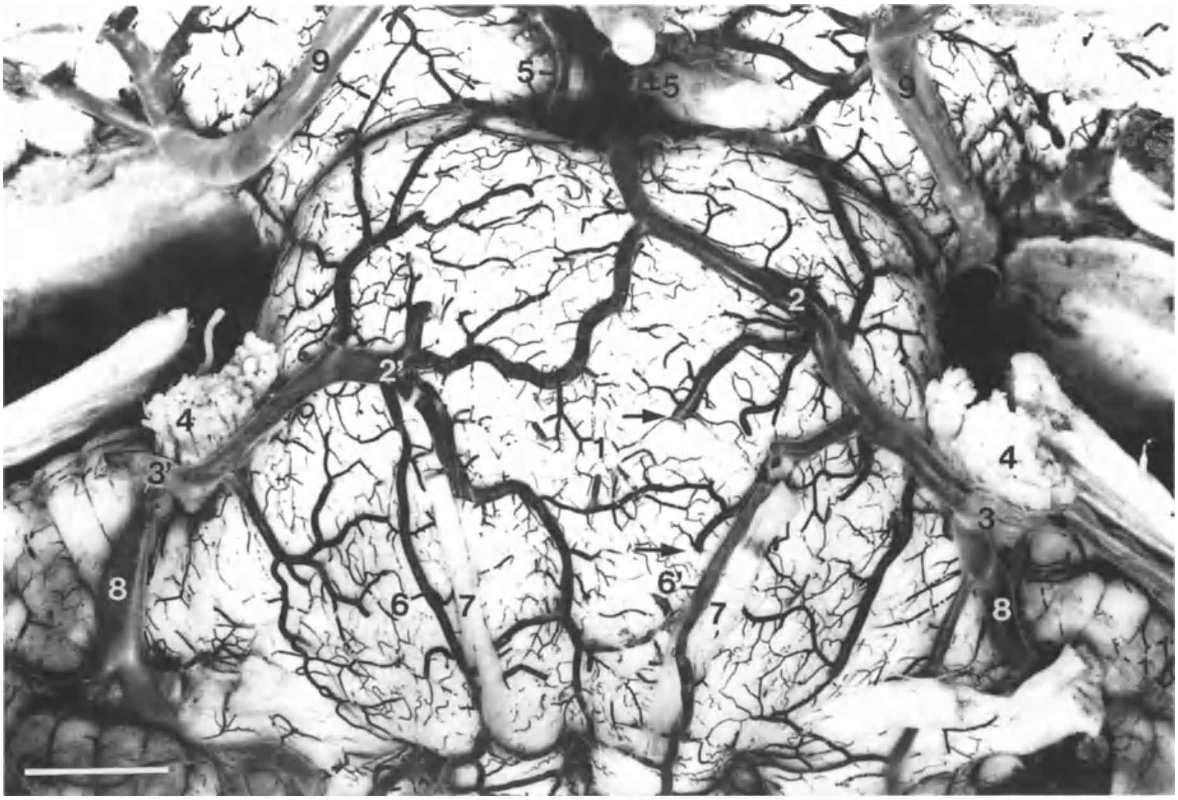
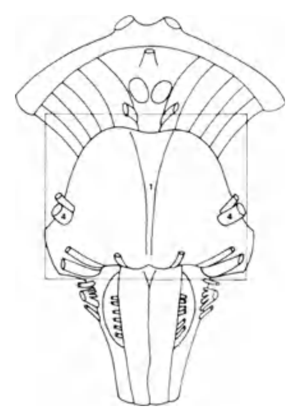


Fig. 58. Anterior View of the Pons. Bar, 4.2 mm



In this case, the longitudinal venous network of the pons is discontinuous and the transverse system is predominant:
1, Basilar sulcus (the median anterior pontine vein is absent); **2** and **2'**, the transverse pontine veins drain the venous network into the superior petrosal veins (**3** and **3'**) exceptionally situated on the anterior side of the trigeminal nerves (**4**). The left transverse pontine veins (**2**) receive the left and right interpeduncular veins (**5**). **6** and **6'**, the lateral anterior pontine veins are satellite of the initial segment of the abducent nerves (**7**); **8**, anterior cerebellar veins; **9**, basal veins
The *arrows* show the emergence of internal anteromedial pontine veins

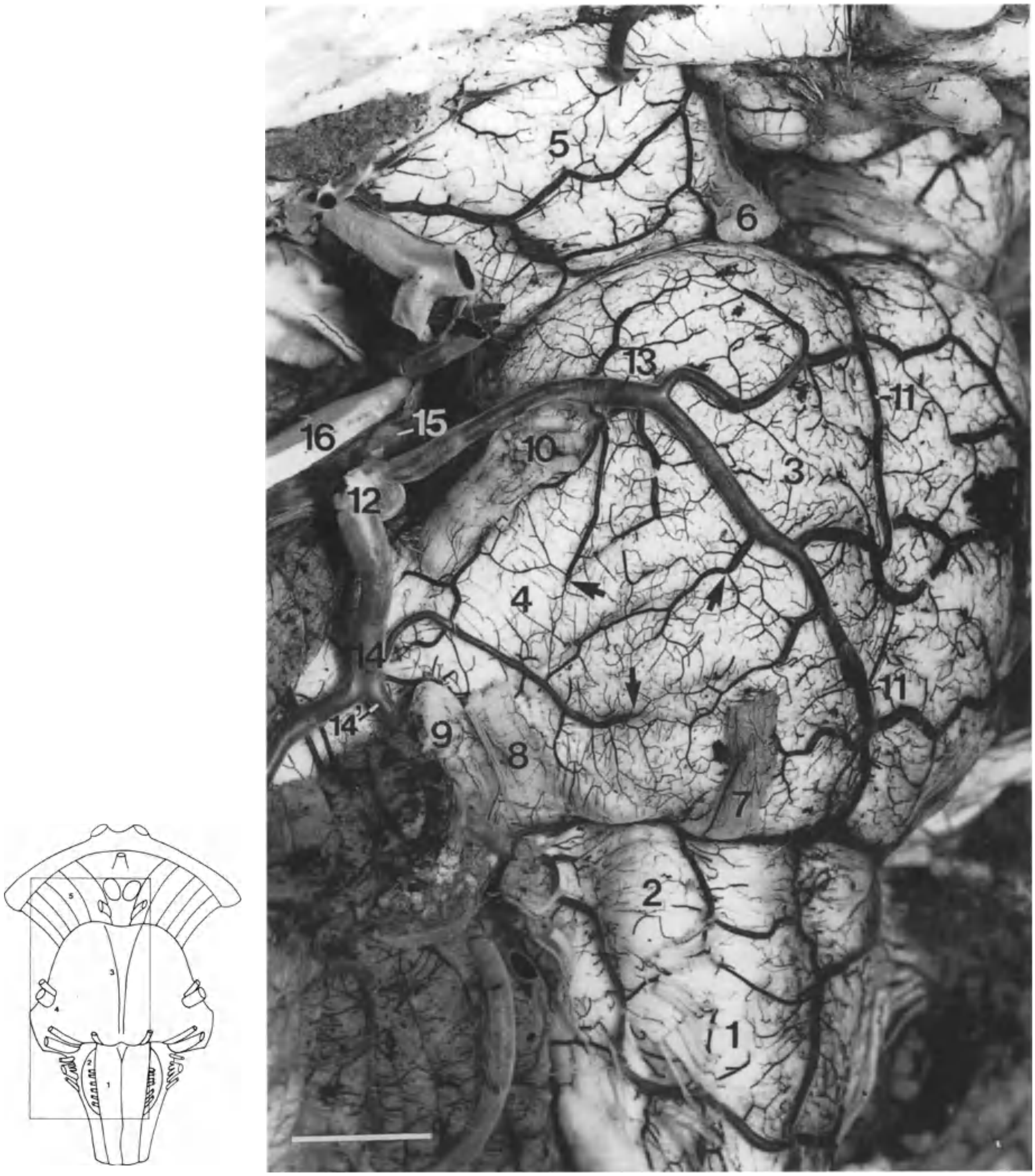
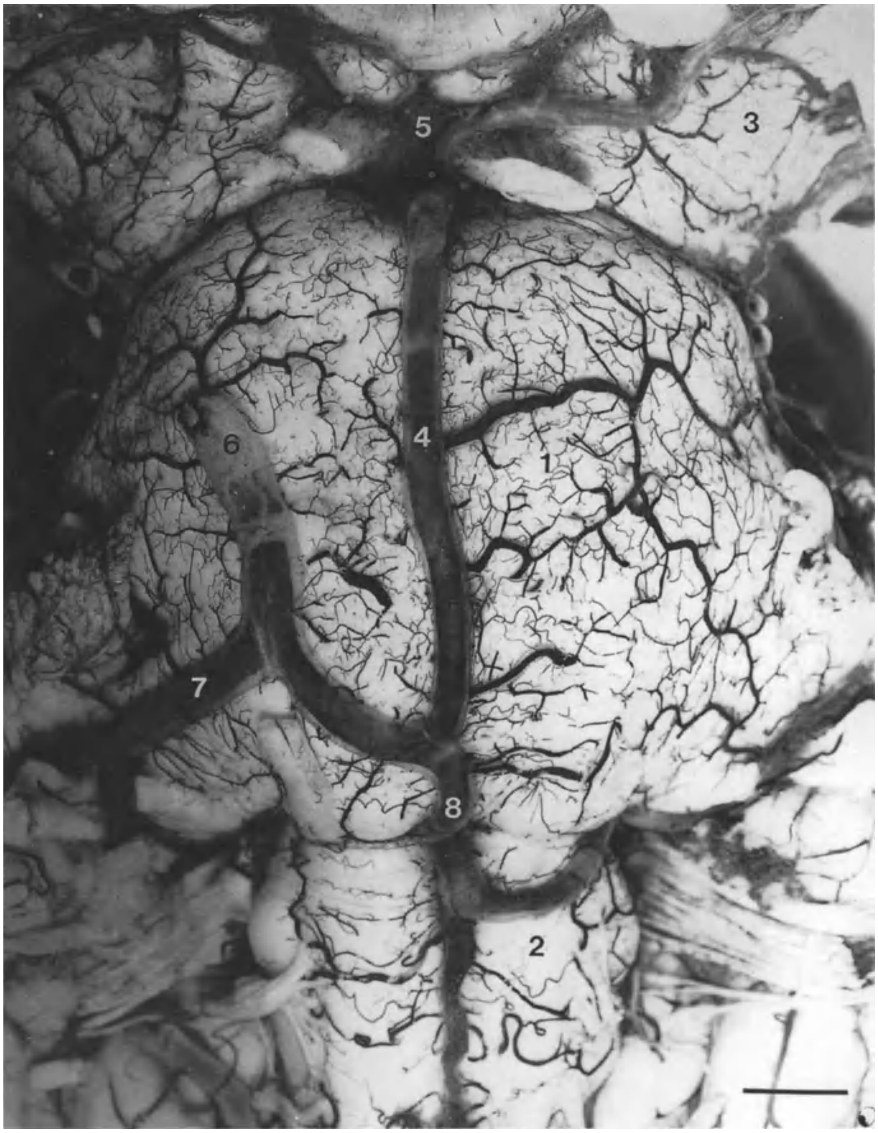


Fig. 59. Right Lateral View of the Brain Stem. Pineal Venous Network After Removal of the Overlapping Superficial Arterial Network. **Bar, 7.5 mm**

1, Pyramid of the medulla; **2**, inferior olive; **3**, basilar part of the pons; **4**, lateral surface of the pons (brachium pontis); **5**, anterior mesencephalic surface (crus cerebri); **6**, oculomotor nerve; **7**, abducent nerve; **8**, facial nerve; **9**, vestibulocochlear nerve; **10**, trigeminal nerve; **11**, median anterior pontine vein. **12**, The *superior petrosal vein* is composed by the union of: **13**, transverse pontine vein; **14**, anterior cerebellar vein (**14'** lateral pontine vein); **15**, lateral mesencephalic vein (Huang and Wolf 1968); **16**, tentorium cerebelli



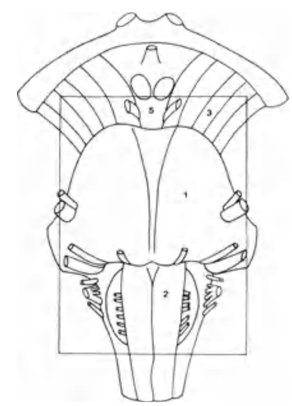


Fig. 60. Anterior View of the Pons After Removal of the Arterial Network. **Bar, 5 mm**

1, Pons; **2**, medulla; **3**, crus cerebri. The pontine veins show many variations. In this case, a large median anterior pontine vein (**4**) (often called pontomesencephalic vein, Huang et al. 1968) emerging from the interpeduncular fossa (**5**) is drained toward the basilar plexus (**6**) and receives a large anterior cerebellar vein (**7**) and the median anterior medullary vein (**8**)

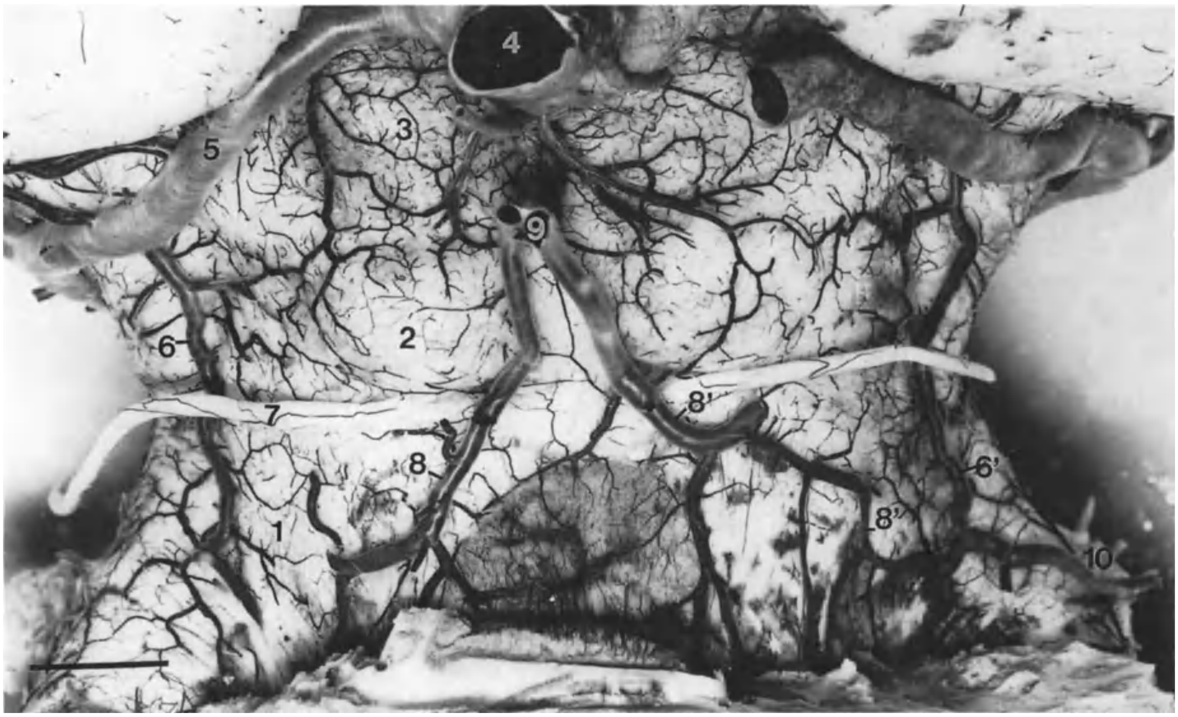
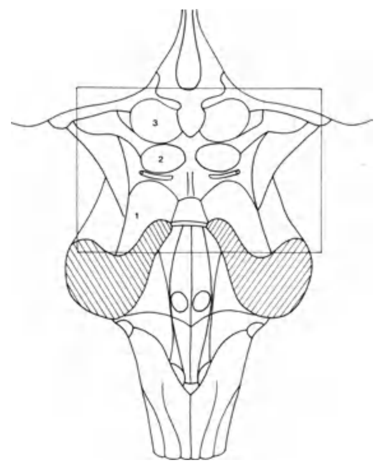


Fig. 61. Posterior View of Pons and Mesencephalon After Removal of Cerebellum. **Bar, 4.8 mm**



1, Superior cerebellar peduncle (brachium conjunctivum); **2**, inferior colliculus; **3**, superior colliculus; **4**, great cerebral vein; **5**, basal vein (laterodorsal segment); **6** and **6'**, lateral mesencephalic veins; **7**, trochlear nerve. The posterior venous network of the pons is mainly made up of the left (**8**) and right (**8'**) veins of the brachia conjunctiva (veins of the superior cerebellar peduncles) which together form the precentral vein (**9**) and are usually linked to the lateral mesencephalic (**6'**) and superior petrosal (**10**) veins

Figures 62–66 show the arterial and venous networks of the anterior (crus cerebri) and lateral surfaces of mesencephalon. The arteries and veins of the posterior surface will be described with the pineal and collicular regions.

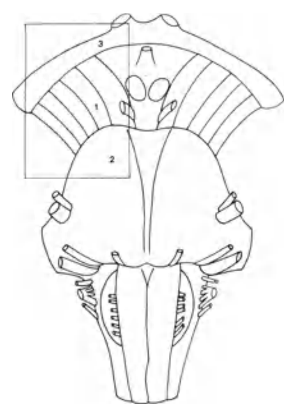


Fig. 62. Anterior View of the Mesencephalon (the temporal lobe has been removed). **Bar, 3.8 mm**

1, Crus cerebri; **2**, pons; **3**, optic tract; **4**, oculomotor nerve; **5**, trochlear nerve; **6**, internal carotid artery; **7**, posterior communicating artery; **8**, anterior choroidal artery reaching the choroid plexuses of the temporal horn (**9**); **10**, basal vein (ventral segment); **11**, posterior cerebral artery; **12**, lateral posterior choroidal artery; **13**, superior cerebellar artery

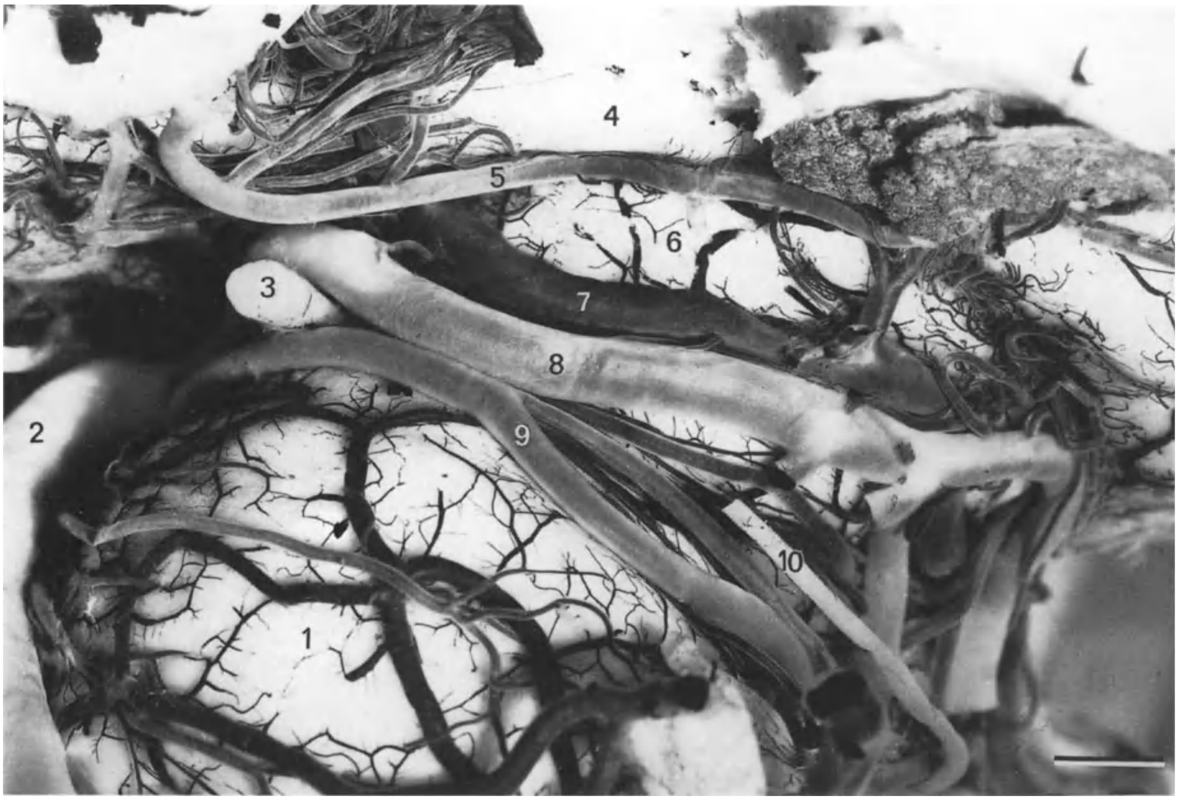
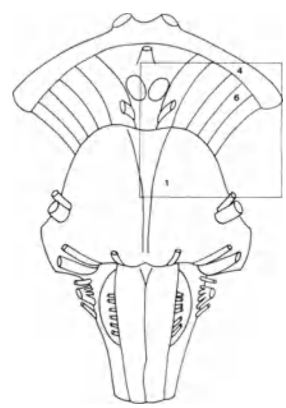


Fig. 63. Anterolateral View of the Left Crus Cerebri
Bar, 4 mm



1, Pons; **2**, basilar artery; **3**, oculomotor nerve; **4**, optic tract; **5**, anterior choroidal artery; **6**, upper part of the crus cerebri; **7**, basal vein; **8**, posterior cerebral artery; **9**, superior cerebellar artery; **10**, trochlear nerve

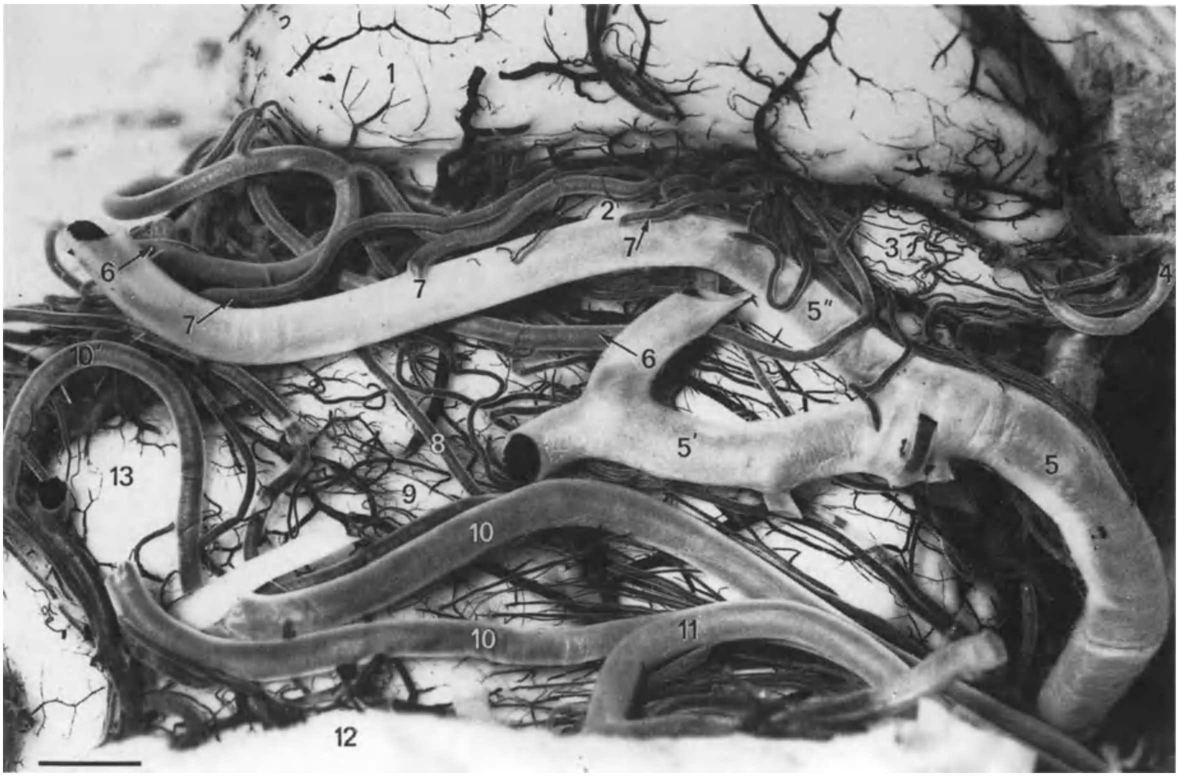
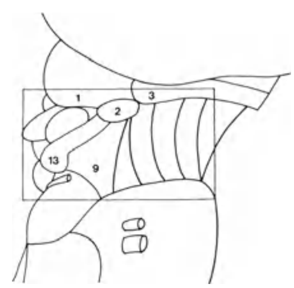
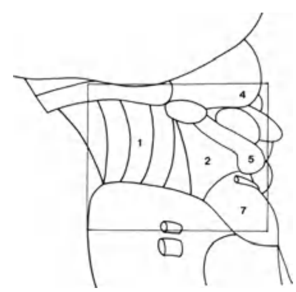


Fig. 64. Right Lateral View of the Mesencephalon Showing the Arrangement of the Main Arterial Trunks. Bar, 3 mm



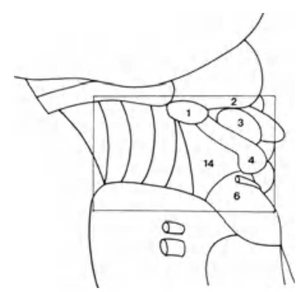
1, Pulvinar; **2**, medial geniculate body; **3**, lateral geniculate body; **4**, lateral posterior choroidal artery; **5**, posterior cerebral artery; **5'**, its temporal branch; **5"**, its occipital branch; **6**, medial posterior choroidal arteries (see p. 48); **7**, thalamogeniculate arteries; **8**, collicular artery; **9**, lateral surface of the mesencephalon (lemniscal trigone); **10**, medial superior cerebellar artery; **10'**, its loop along the superior margin of the inferior colliculus (**13**); **11**, lateral superior cerebellar artery; **12**, cut surface of the cerebellum; **13**, inferior colliculus. The dorsolateral segment of the basal vein is absent

Fig. 65. Left Lateral View of the Mesencephalon. **Bar, 3 mm**



1, Crus cerebri; **2**, lateral mesencephalic surface; **3**, medial geniculate body; **4**, pulvinar; **5**, inferior colliculus; **6**, trochlear nerve; **7**, superior cerebellar peduncle (brachium conjunctivum); **8**, trigeminal nerve. Vascular trunks circling the mesencephalon (the posterior cerebral artery has been removed from this dissection): **9**, basal vein, laterodorsal segment (**9′** vein of the temporal horn of the lateral ventricle); **10**, medial posterior choroidal artery; **10′**, its branches belonging to the lateral group of mesencephalic arteries; **11**, collicular artery; **12**, superior cerebellar artery; **12′**, lateral branch; **12″**, medial branch; **12‴**, supernumerary branch. **13**, Lateral mesencephalic vein; **14**, lateral group of mesencephalic arteries; **15**, thalamic branches arising from the medial posterior choroidal artery; **16**, thalamogeniculate arteries, branches of posterior cerebral artery

Fig. 66. Left Lateral View of the Mesencephalon (after removal of the posterior cerebral artery and of the dorsolateral segment of the basal vein). **Bar, 2.5 mm**



1, Medial geniculate body; **2**, pulvinar; **3**, superior colliculus; **4**, inferior colliculus; **5**, vein of the brachium conjunctivum (vein of the superior cerebellar peduncle); **6**, superior cerebellar peduncle (brachium conjunctivum); **7**, lateral superior cerebellar artery and; **7'**, its branches supplying the posterior area of the lateral surface of the pons; **8** and **8'**, medial superior cerebellar artery; **9**, its lateral rami belonging to the lateral group and reaching the lateral mesencephalic surface (**14**); **10**, collicular artery; **10'** and **10''**, its superior and inferior terminal branches; **11**, accessory collicular artery; **12**, lateral mesencephalic vein; **13**, medial posterior choroidal artery displaced upwards; **14**, lateral surface of the mesencephalon (lemniscal trigone)

Figures 67–74 show the venous network of the anterior (crus cerebri) and lateral surfaces of mesencephalon after removal of the arteries. The veins of the posterior surface will be described with those of the pineal region. The basal vein, which is the main venous trunk on the anterior and lateral sides of the mesencephalon, will be briefly described. (For more details, in particular concerning the variations of this vein, see DUVERNOY 1975).

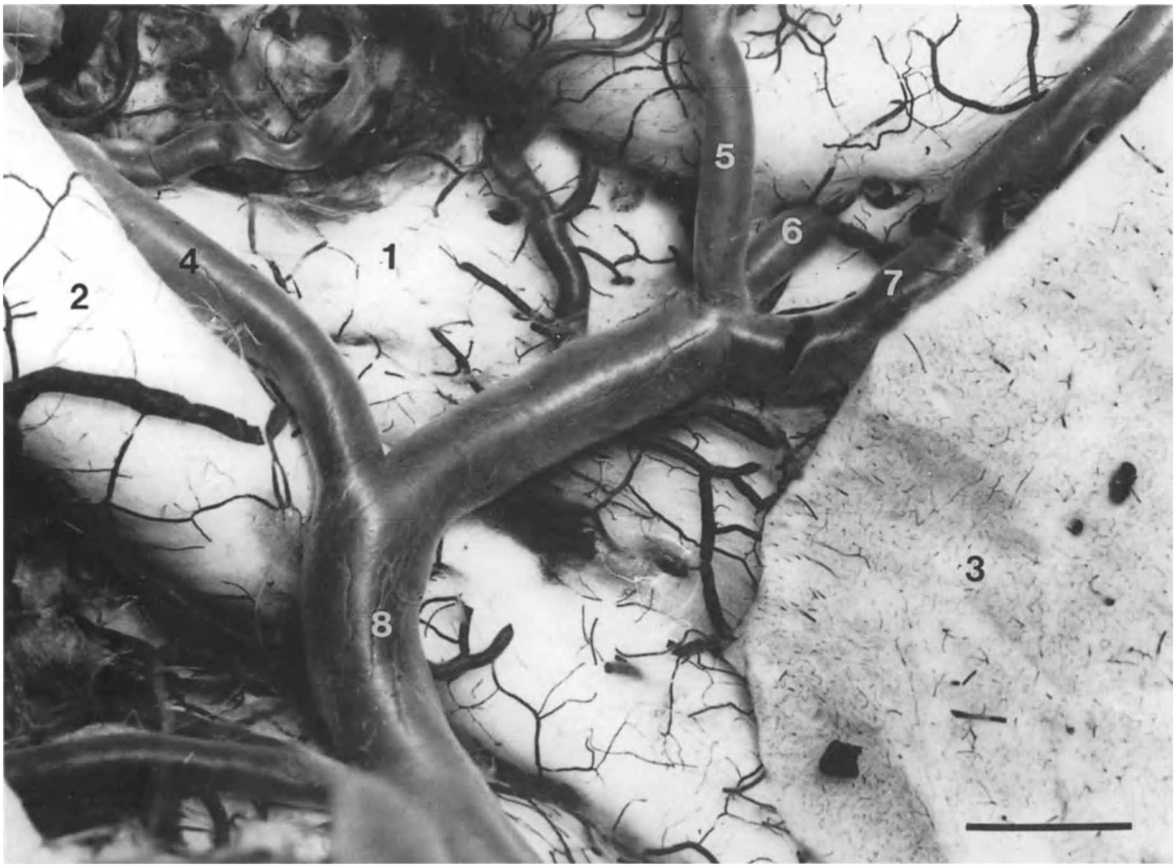
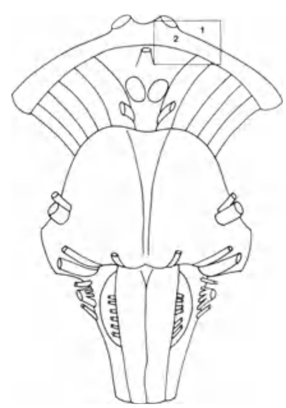


Fig. 67. Ventral View of the Left Anterior Perforated Substance Showing the Origin of the Basal Vein After Ablation of the Arterial Network. **Bar, 2 mm**



1, Left anterior perforated substance; **2**, optic tract; **3**, cut surface of temporal lobe. The origin of the basal vein is typically formed by the junction of: **4**, anterior cerebral vein; **5**, veins of the orbital lobe; **6**, inferior striate vein; **7**, deep middle cerebral vein. **8**, Ventral (first) segment of the basal vein

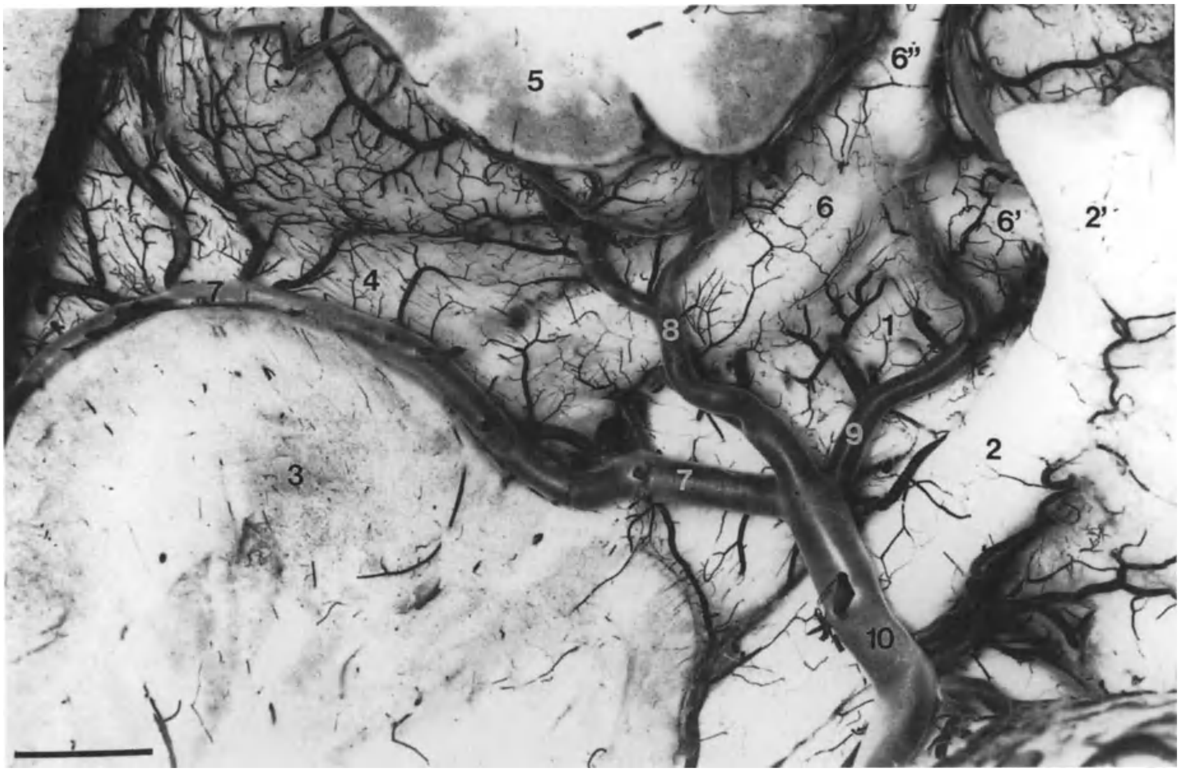
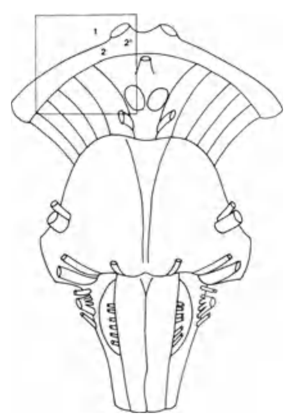


Fig. 68. Ventral View of the Right Anterior Perforated Substance Showing the Origin of the Basal Vein After Ablation of the Arterial Network. **Bar, 4 mm**



1, Right anterior perforated substance; **2**, optic tract; **2′**, optic chiasma; **3**, cut surface of the temporal lobe; **4**, limen insulae; **5**, cut surface of the orbital lobe; **6**, lateral olfactory stria; **6′**, medial olfactory stria; **6″**, olfactory tract. The branches of origin of the basal vein are limited in this case to: **7**, deep middle cerebral vein located in the basal segment of the lateral fissure; **8**, veins of the orbital lobe; **9**, inferior striate veins (the anterior cerebral vein is lacking). **10**, Ventral (first) segment of the basal vein

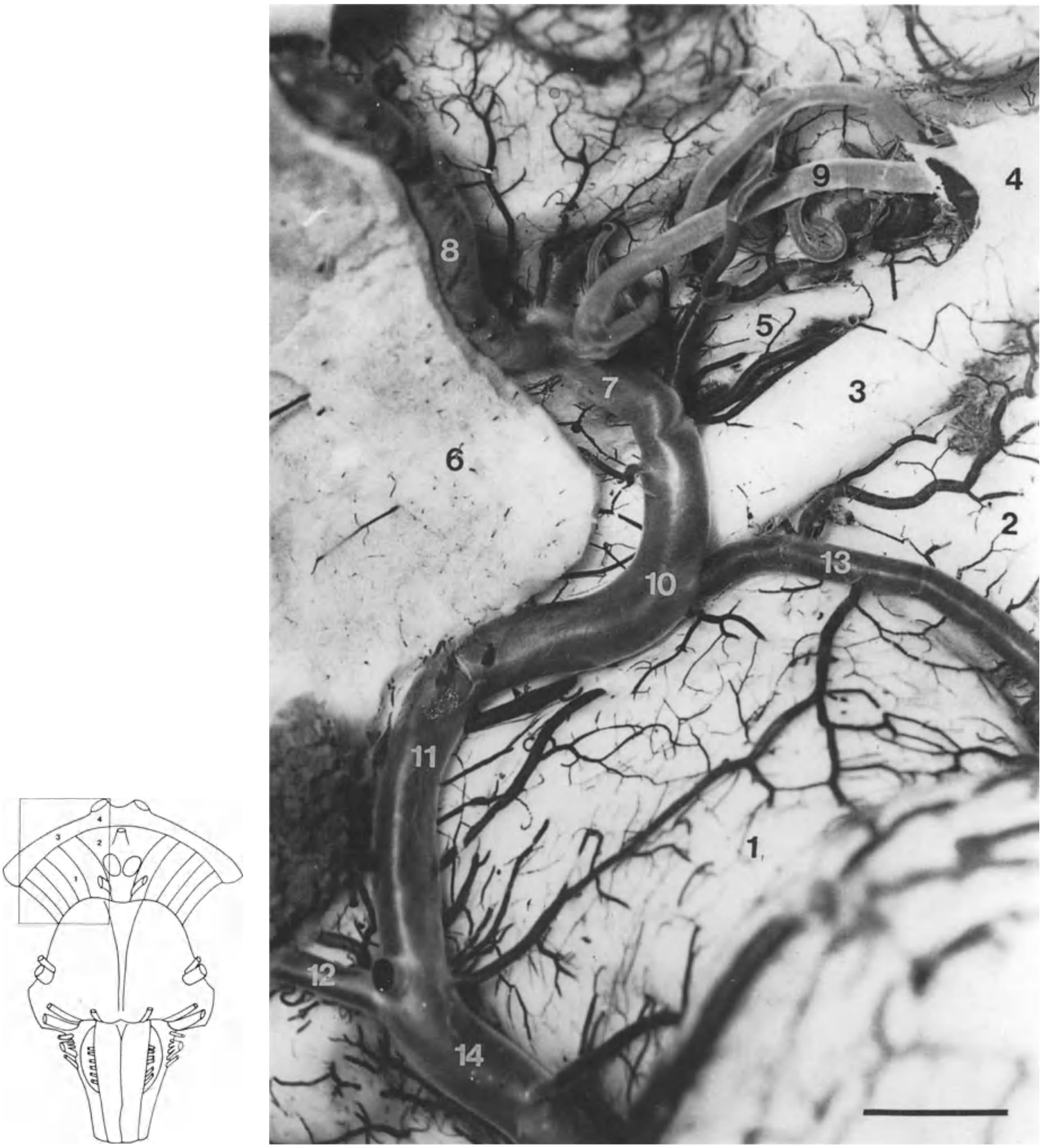


Fig. 69. Ventral View of the Right Crus Cerebri Showing the Ventral (First) Segment of the Basal Vein. **Bar, 3.9 mm**

1, Crus cerebri; **2**, tuber cinereum; **3**, optic tract; **4**, optic chiasma; **5**, anterior perforated substance; **6**, cut surface of temporal lobe; **7**, origin of the basal vein; **8**, deep middle cerebral vein; **9**, recurrent artery (of Heubner). The ventral (first) segment of the basal vein has a curved aspect: **10**, concave laterally; **11**, concave medially around the crus cerebri. **12**, Vein of the temporal horn of the lateral ventricle (inferior ventricular vein); **13**, interpeduncular vein; **14**, beginning of the laterodorsal (second) segment of the basal vein

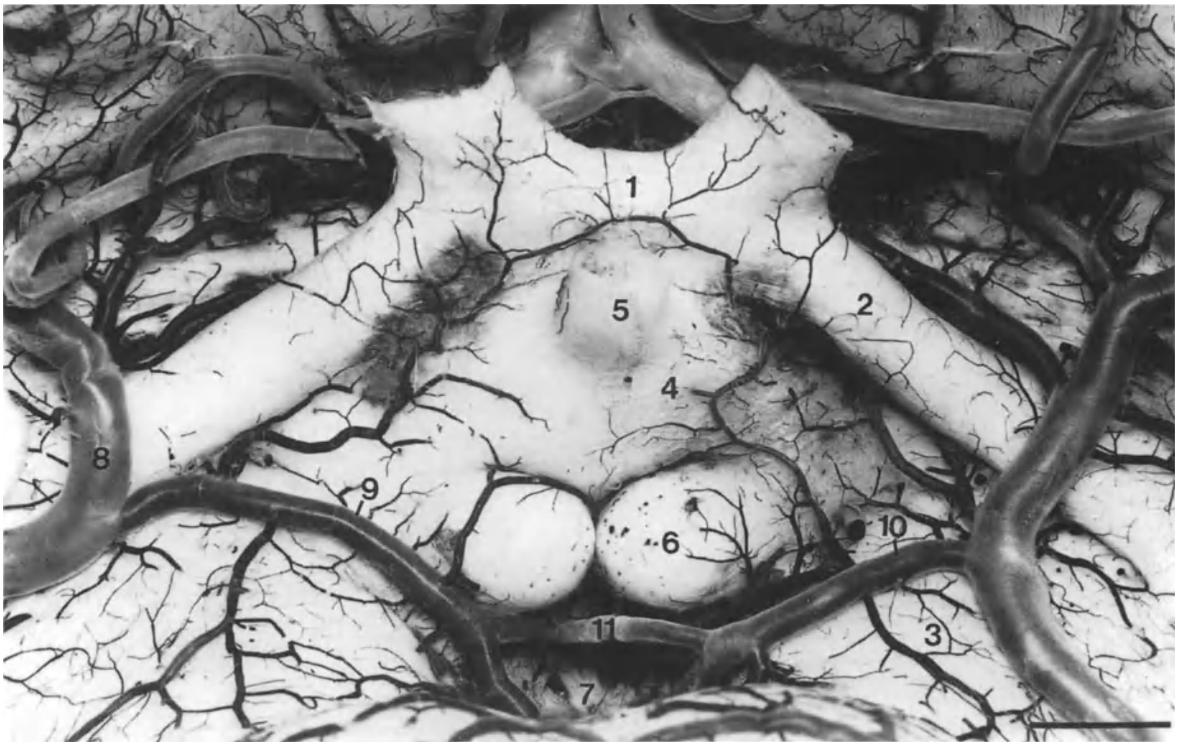
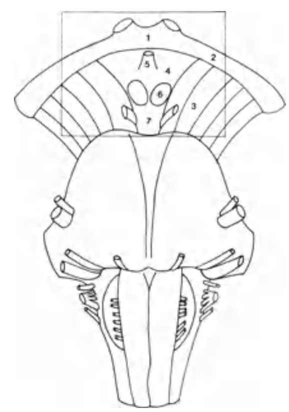


Fig. 70. Veins of the Interpeduncular Region After Ablation of the Arterial Network. **Bar, 4 mm**



1, Optic chiasma; **2**, optic tract; **3**, crus cerebri; **4**, tuber cinereum; **5**, median eminence of the hypophysis; **6**, mamillary bodies; **7**, interpeduncular fossa. The ventral segment of the right basal vein (**8**) receives the right interpeduncular vein (**9**) which is linked to the left interpeduncular vein (**10**) by the posterior communicating vein (**11**). The interpeduncular region is limited by the optic chiasma (**1**), optic tract (**2**) and crus cerebri (**3**). It includes the tuber cinereum (**4**), the median eminence of the hypophysis (**5**), the mamillary bodies (**6**), and the interpeduncular fossa (**7**)

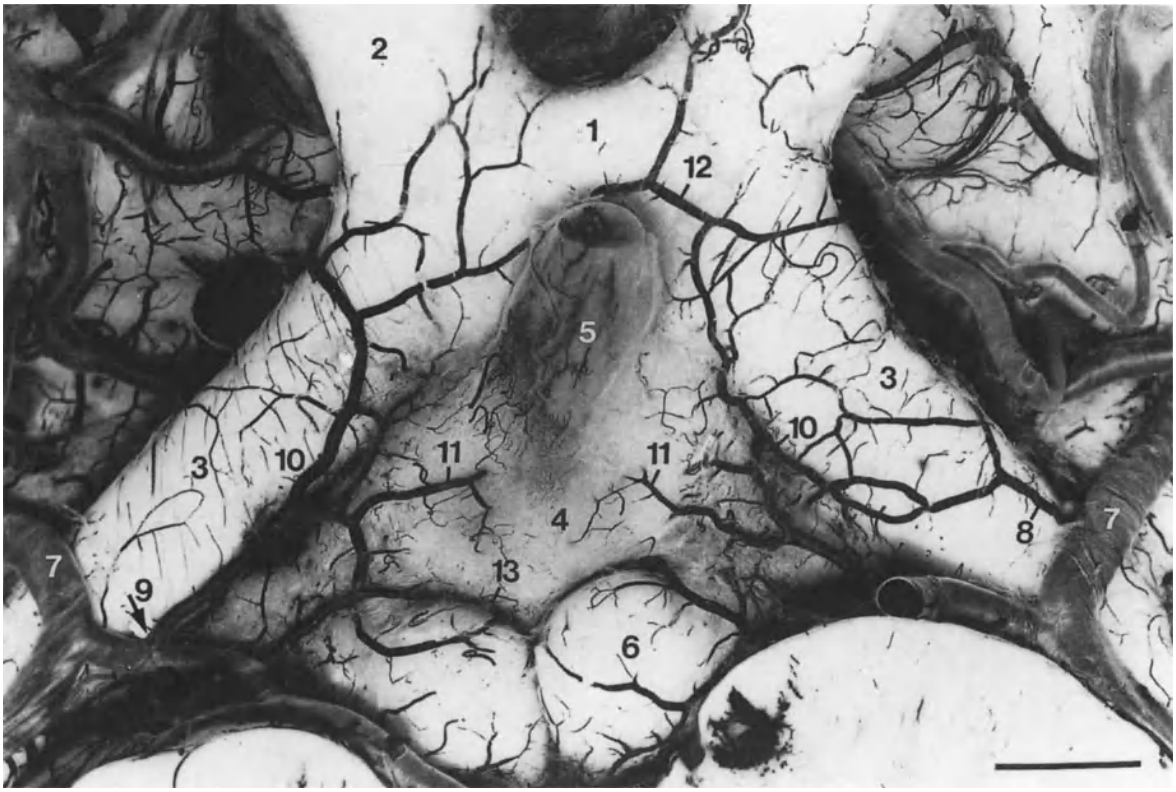
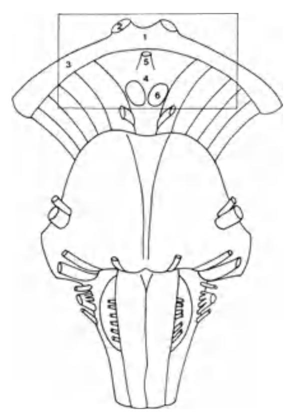


Fig. 71. Veins of the Interpeduncular Area After Ablation of the Arterial Network. **Bar, 4 mm**



The ventral segments of the basal veins (**7**) receive directly (**8**) or through the interpeduncular vein (**9**), the right and left longitudinal tuberal veins (**10**) which drain the medial tuberal veins (**11**) and are linked together by the retrochiasmatic (**12**) and the premamillary (**13**) venous arches. **1**, Optic chiasma; **2**, optic nerve; **3**, optic tracts; **4**, tuber cinereum; **5**, hypophysial stalk; **6**, mamillary body

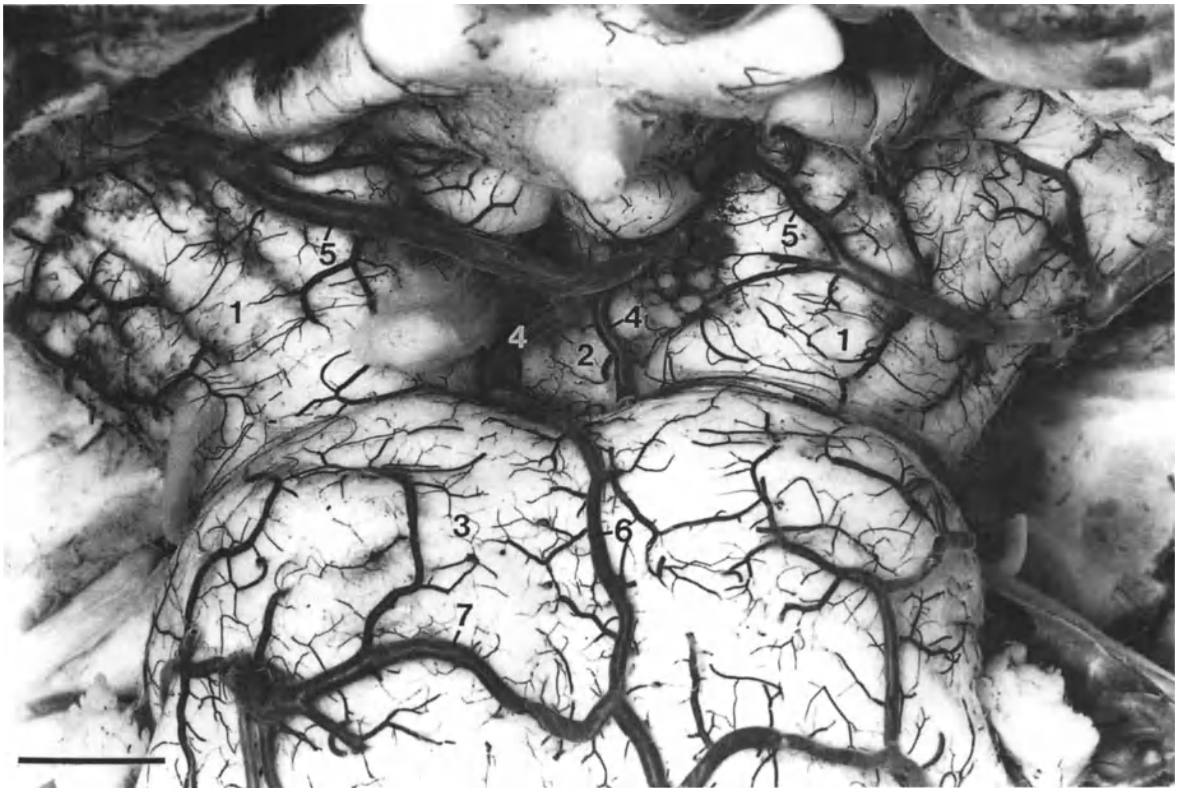
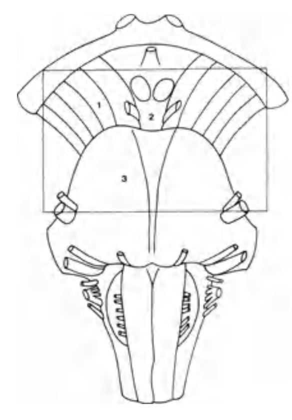


Fig. 72. Veins of the Interpeduncular Fossa After Ablation of the Arterial Network. **Bar, 4.8 mm**



1, Crus cerebri (pes pedunculi); **2**, interpeduncular fossa; **3**, pons. The right and left veins of the interpeduncular fossa (**4**) flow into the interpeduncular veins (**5**) and receive the median anterior pontine vein (**6**). **7**, Transverse pontine vein

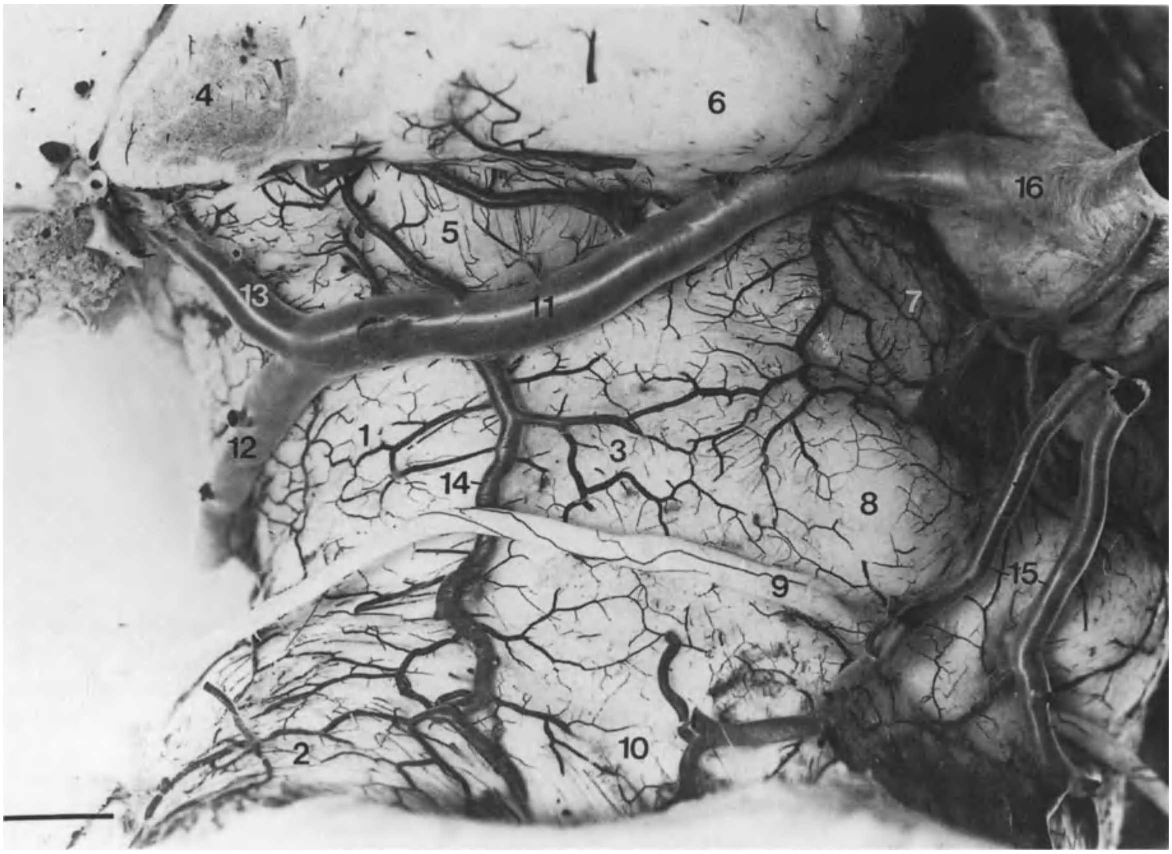
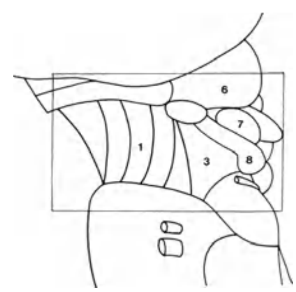
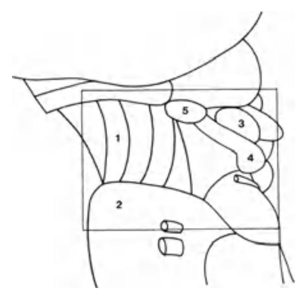


Fig. 73. Left Lateral View of Mesencephalon Showing the Laterodorsal Segment of the Basal Vein (11) After Removal of the Arterial Network. **Bar, 7.4 mm**



1, Crus cerebri; **2**, pons; **3**, lateral mesencephalic surface; **4**, lateral geniculate body (cut surface); **5**, medial geniculate body; **6**, pulvinar; **7**, superior colliculus; **8**, inferior colliculus; **9**, trochlear nerve; **10**, superior cerebellar peduncle (brachium conjunctivum); **11**, laterodorsal segment of the basal vein; **12**, ventral segment of the basal vein; **13**, vein of the temporal horn of the lateral ventricle (inferior ventricular vein); **14**, lateral mesencephalic vein; **15**, veins of the brachia conjunctiva (veins of the superior cerebellar peduncles). The laterodorsal segment of the basal vein is drained into the great cerebral vein (**16**)

Fig. 74. Left Lateral View of Mesencephalon After Ablation of the Arterial Network. **Bar, 4.2 mm**



1, Crus cerebri; **2**, pons; **3**, superior colliculus; **4**, inferior colliculus; **5**, medial geniculate body; **6**, laterodorsal segment of the basal vein; **7**, superior petrosal vein. In its most typical aspect, the lateral mesencephalic vein (**8**) links the basal vein (**6**) to the superior petrosal vein (**7**) and receives the vein of the brachium conjunctivum (**9**). **10**, Anterior cerebellar vein; **11**, vein of the pontomesencephalic sulcus; **12**, trochlear nerve

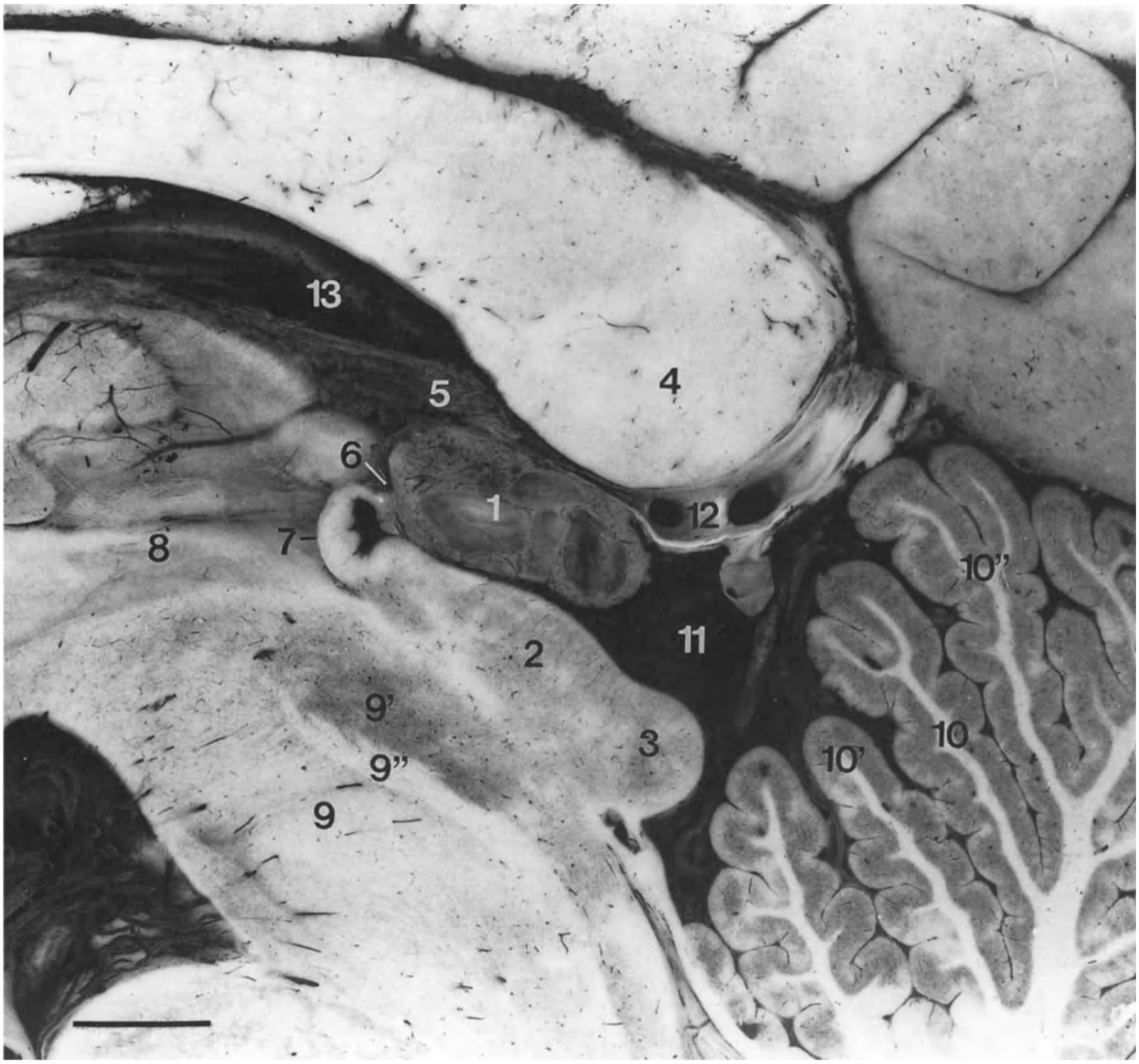


Fig. 75. Median Sagittal Section Showing the Structures Included in the Pineal and Collicular Regions. **Bar, 4.7 mm**

1, Pineal gland. **2**, superior colliculus. **3**, inferior colliculus. **4**, splenium of corpus callosum; **5**, suprapineal recess and choroid plexuses; **6**, pineal recess; **7**, posterior commissure; **8**, third ventricle; **9**, cerebral peduncle; **9'**, oculomotor nuclei; **9"**, medial longitudinal fasciculus; **10**, superior vermis; **10'**, central lobule ; **10"**, culmen; **11**, quadrigeminal (collicular) cistern; **12**, great cerebral vein; **13**, internal cerebral vein

Figures 76–79 show dissections of the pineal region from upper to lower levels (after removal of the splenium and fornix).

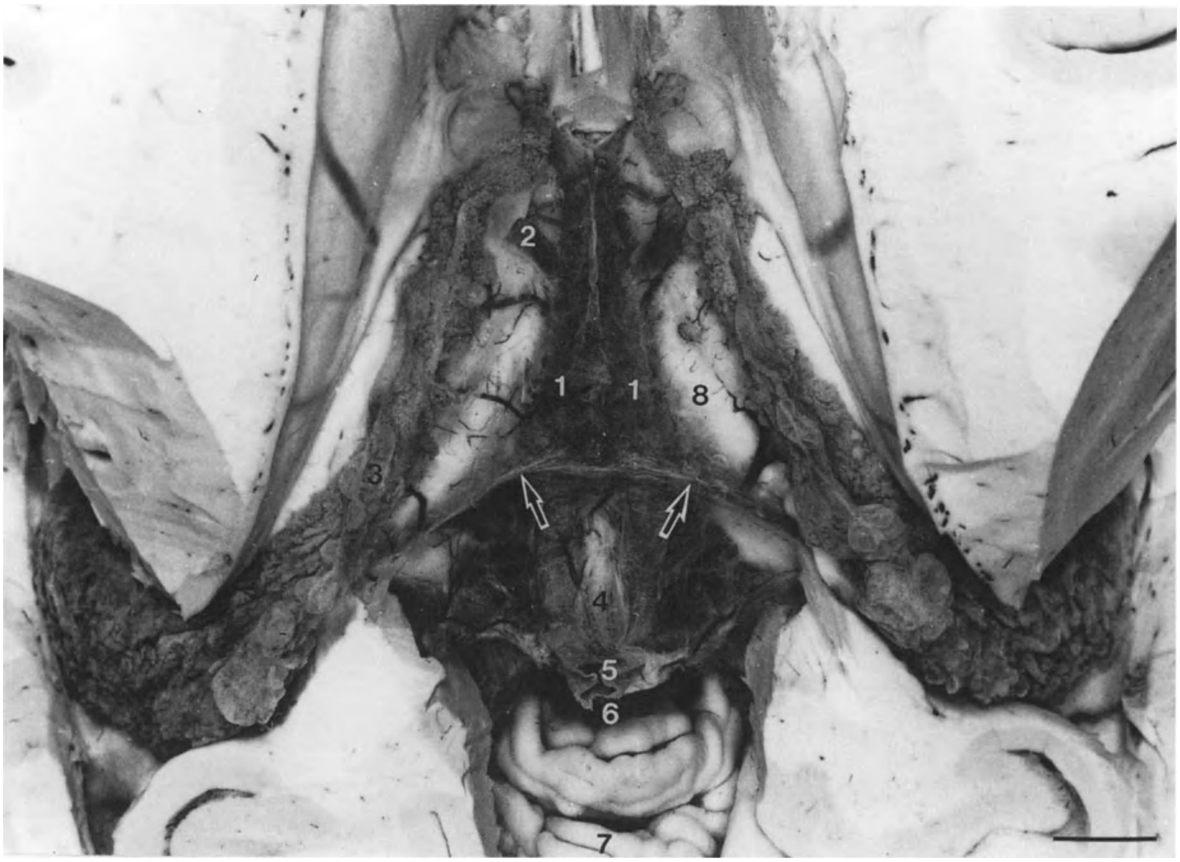
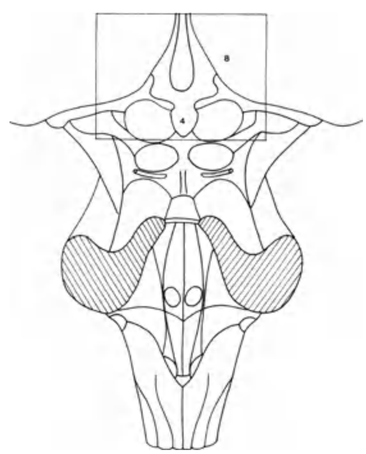


Fig. 76. Superior View of the Pineal Region After Removal of the Splenium and Fornix. **Bar, 8 mm**



The internal cerebral veins (**1**) are seen in transparency through the fine superior (prosencephalic) tela choroidea (*arrows*). **2**, Thalamostriate vein; **3**, choroid plexuses of lateral ventricle; **4**, suprapineal recess and pineal gland ; **5**, great cerebral vein; **6**, quadrigeminal cistern; **7**, culmen of vermis; **8**, superior thalamic surface

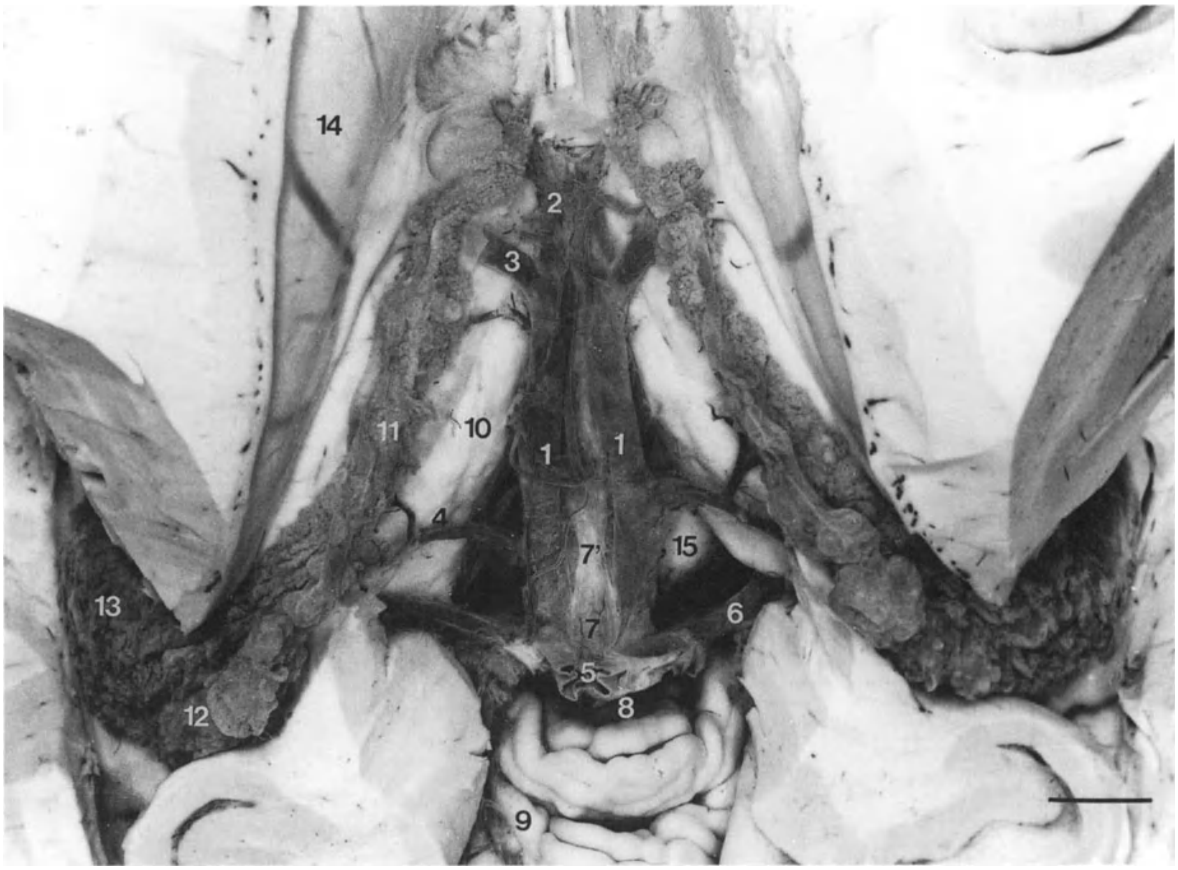
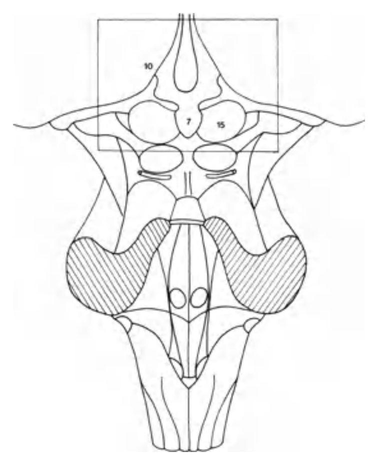


Fig. 77. Superior View of the Pineal Region. After ablation of the pial layers of the tela choroidea, the internal cerebral veins (1) are more clearly visible. **Bar, 8 mm**



1, Internal cerebral veins; **2**, septal vein; **3**, thalamostriate vein; **4**, medial atrial vein (posterior ventricular vein) (see JOHANSON 1954; WOLF and HUANG 1964; BEKOV 1965; BILLEWICZ and BEN AMOR 1970; STEIN and ROSENBAUM 1974).
5, Great cerebral vein ; **6**, basal vein. The pineal gland (**7**) and the suprapineal recess (**7'**) are situated between the two internal cerebral veins. **8**, Quadrigeminal cistern; **9**, culmen; **10**, thalamus (superior aspect); **11**, choroid plexuses of the body of lateral ventricle; **12**, choroid glomus; **13**, choroid plexuses of the temporal horn; **14**, caudate nucleus; **15**, superior colliculus

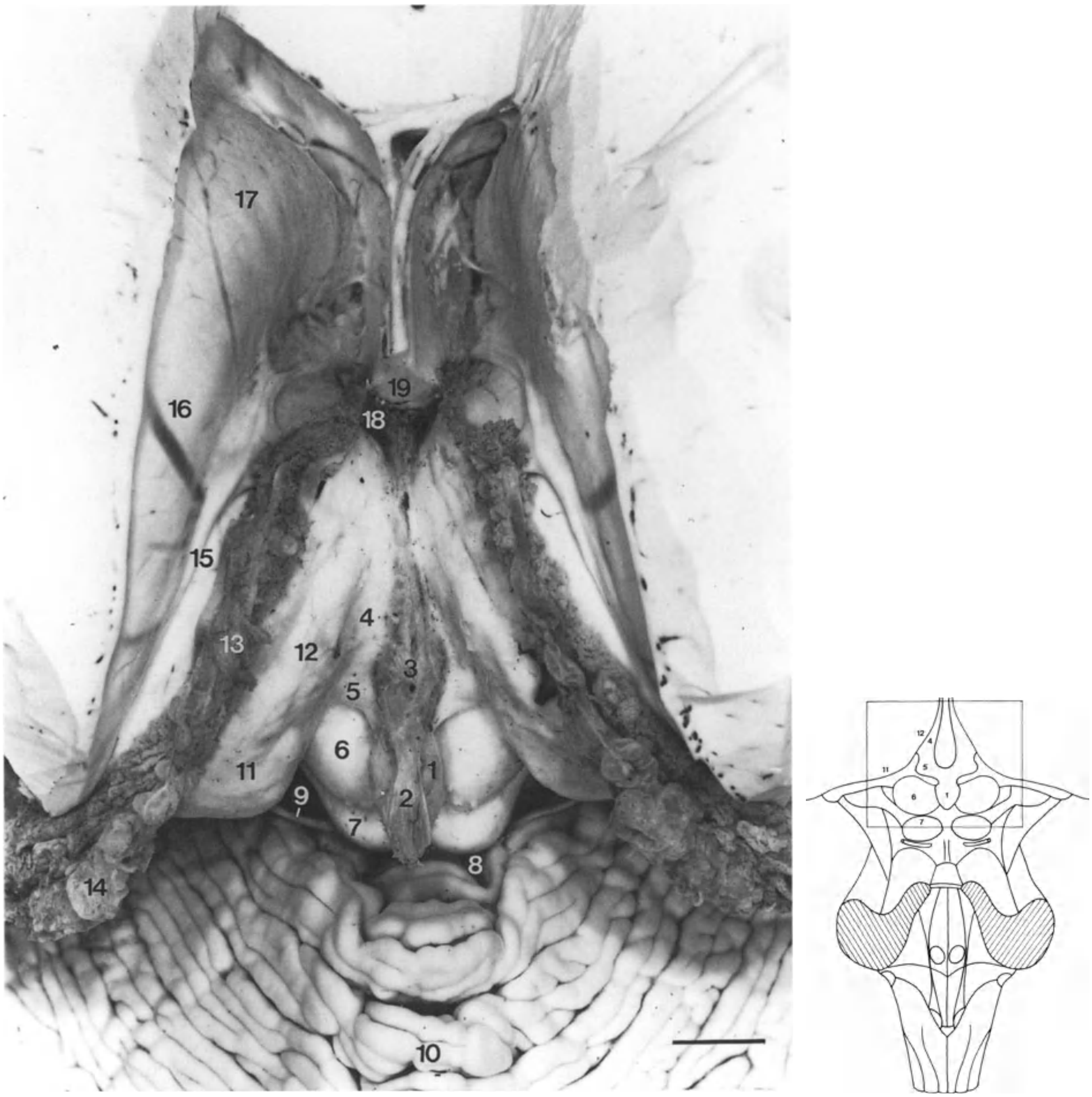


Fig. 78. Superior View of the Pineal Region After Removal of the Internal and Great Cerebral Veins. **Bar, 8 mm**

1, Pineal gland (superior surface); **2**, suprapineal recess; **3**, membrana tectoria (roof of the third ventricle); **4**, stria medullaris; **5**, habenular trigone; **6**, superior colliculus; **7**, inferior colliculus; **8**, quadrigeminal cistern; **9**, trochlear nerve; **10**, culmen; **11**, pulvinar; **12**, thalamus, superior aspect; **13**, choroid plexuses of the body of the lateral ventricle; **14**, choroid glomus; **15**, thalamostriate (terminal) sulcus; **16**, caudate nucleus (body); **17**, caudate nucleus (head); **18**, interventricular foramen; **19**, section of the fornix

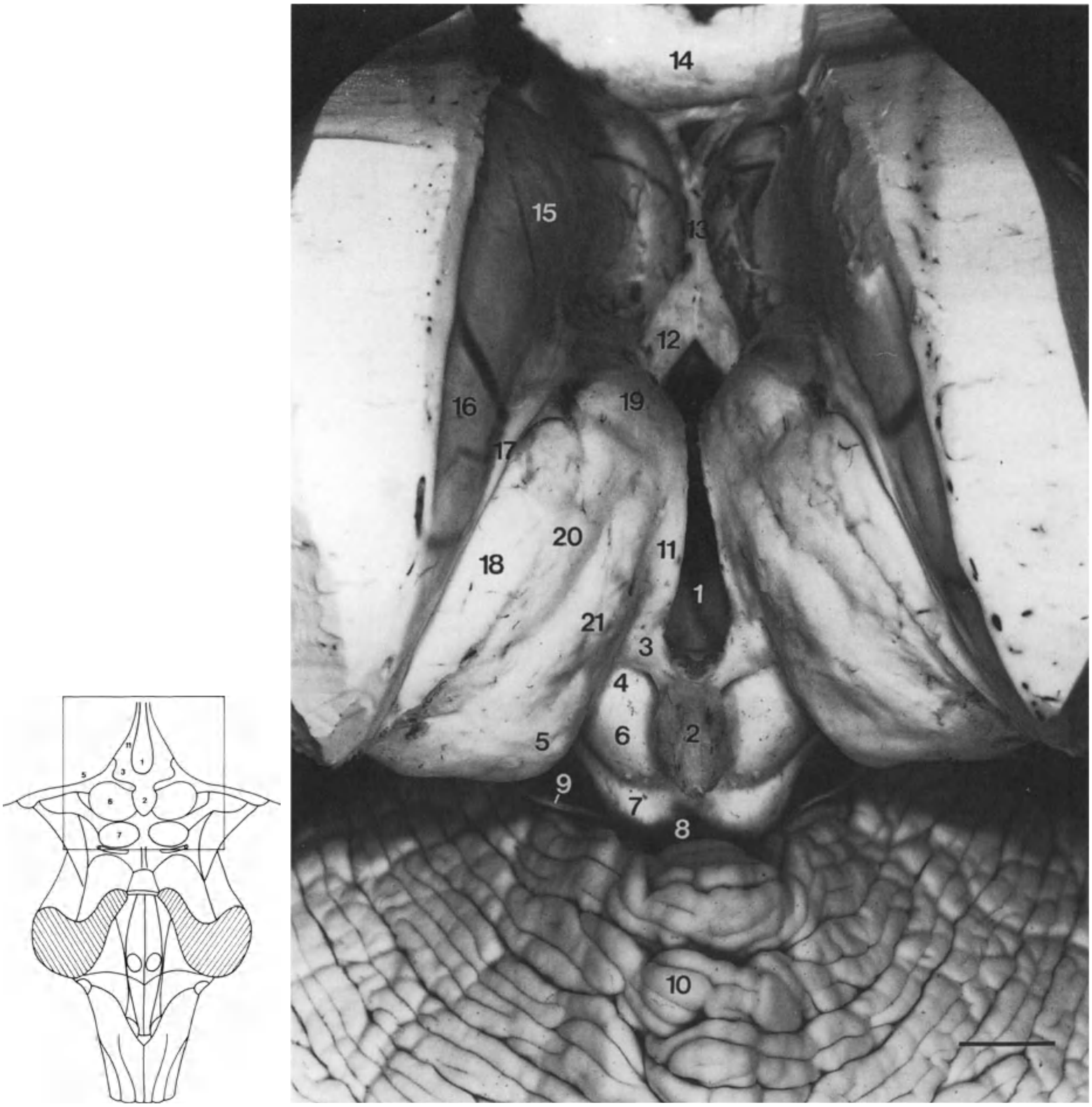
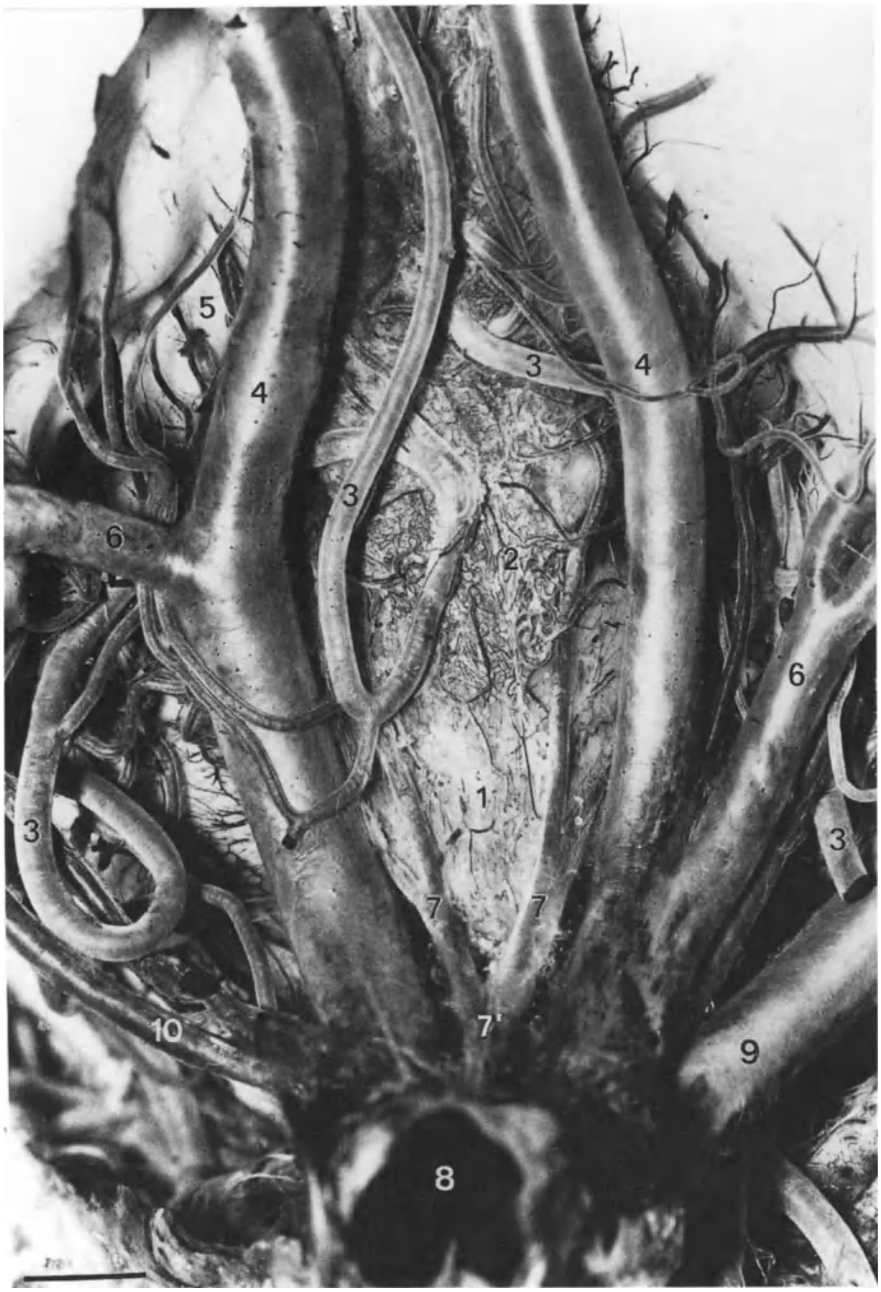


Fig. 79. Superior View of the Pineal Region After Ablation of the Choroid Plexuses of the Lateral Ventricle (and of those of the third ventricle which has been opened) (**1**). **Bar, 8 mm**

1, Third ventricle; **2**, pineal gland (note its cone-shaped aspect); **3**, habenular trigone (habenular nucleus); **4**, pretectal area; **5**, pulvinar; **6**, superior colliculus; **7**, inferior colliculus; **8**, quadrigeminal cistern; **9**, trochlear nerve; **10**, culmen; **11**, stria medullaris; **12**, column of fornix; **13**, septum pellucidum ; **14**, genu of corpus callosum; **15**, head of caudate nucleus; **16**, body of caudate nucleus. **17**, The thalamostriate (terminal) sulcus includes the thalamostriate vein and the stria terminalis covered and hidden by a thickening of lamina affixa (**18**). **18**, Lamina affixa; **19**, anterior thalamic nucleus; **20**, lateral thalamic nuclei; **21**, mediodorsal thalamic nucleus

Figures 80–87 show dissections of arteries and veins of the pineal region as well as blood vessels of the pineal gland (for the study of the pineal vascular network in sections, see Figs. 170–175).



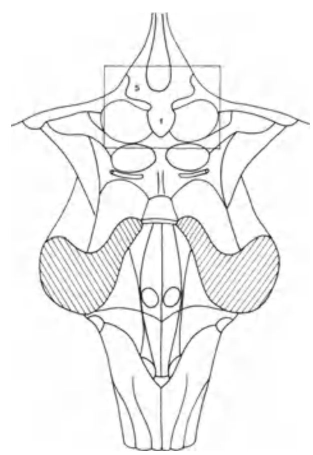


Fig. 80. Superior View of the Blood Vessels of the Pineal Region (the corpus callosum has been removed) (intravascular india ink injection). **Bar, 2.5 mm**

1, Pineal gland; **2**, suprapineal recess; **3**, medial posterior choroidal arteries; **4**, internal cerebral veins; **5**, habenular trigone; **6**, medial atrial veins (posterior ventricular veins, see Fig. 77); **7**, lateral pineal veins draining into the great cerebral vein through a single trunk **7'** (median pineal vein); **8**, great cerebral vein; **9**, right basal vein. **10**, The left basal vein is small in diameter (accessory basal vein, DUVERNOY 1975). The superior aspect of the pineal gland (**1**) appears between the two large internal cerebral veins (**4**)

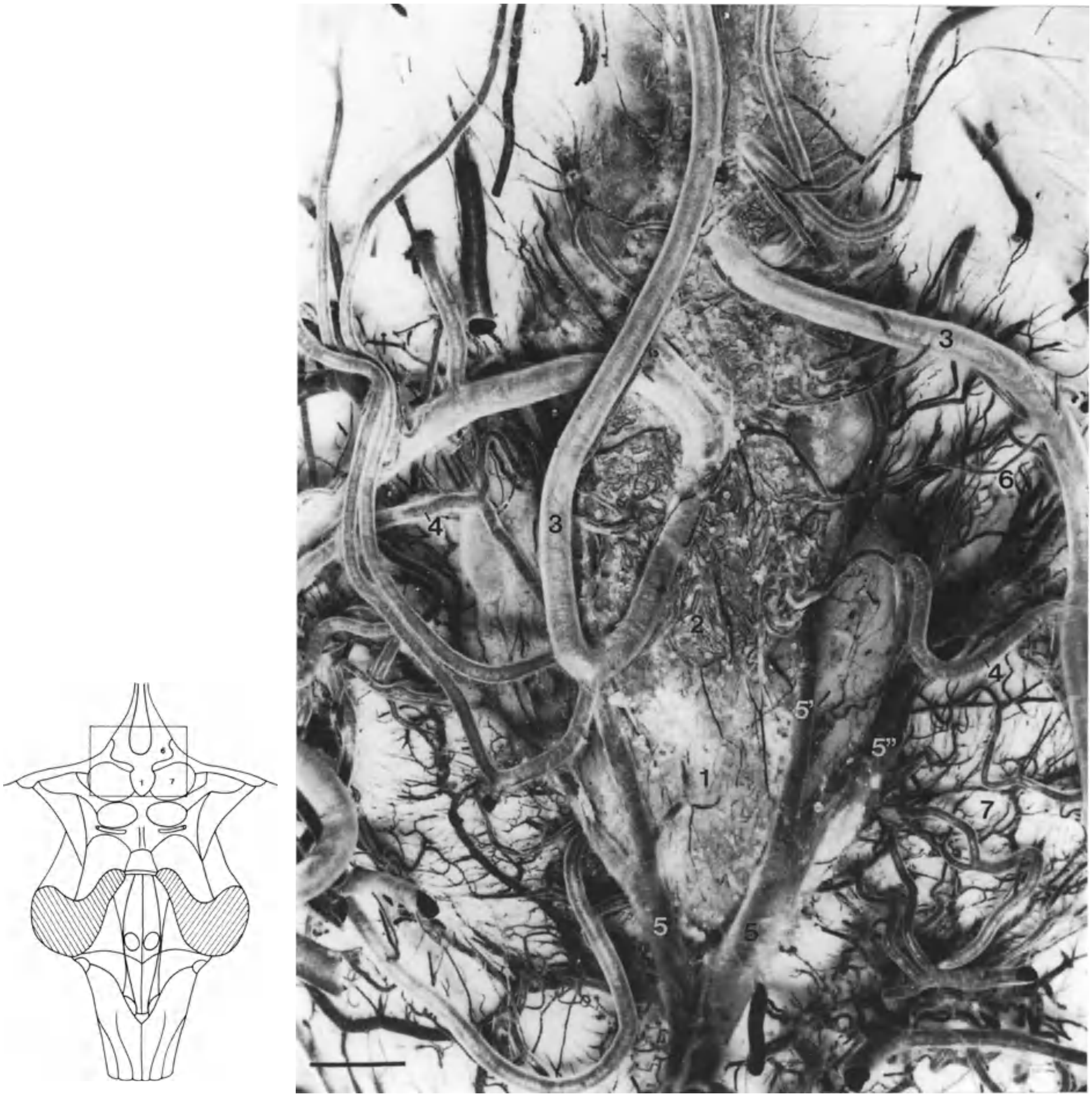


Fig. 81. Superior View of the Pineal Gland After Removal of the Internal Cerebral Veins (intravascular india ink injection). Bar, 1.8 mm

1, Pineal gland; 2, suprapineal recess. 3, The right and left medial posterior choroidal arteries have a sinuous path on the superior surface of the pineal gland. 4, Branches of the medial posterior choroidal artery supplying the pineal gland (pineal arteries). 5, The right and left lateral pineal veins are composed of two superior (5′) and inferior (5″) branches draining the blood of the pineal gland, the habenular trigone (6) and part of the pretectal area and superior colliculus (see Fig. 93). 7, Superior colliculus. For more information about the vascular supply of the pineal gland, see Guidicelli and Salamon 1970; Tamaki et al. 1973; Rosenbaum and Stein 1974; Schlessinger 1976; Yamamoto and Kageyama 1980; and Reiter 1981

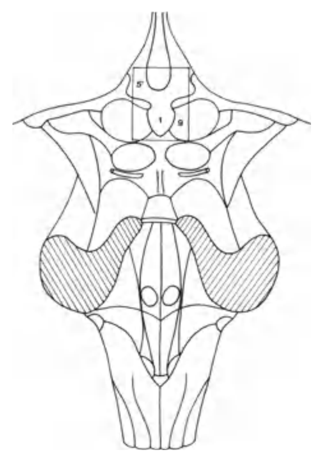


Fig. 82. Superior View of the Pineal Gland (intravascular india ink injection). Same preparation as in Fig. 81. (See Figs. 170–175 for the internal vascularization of the pineal gland)
Bar, 1.5 mm

1, Pineal gland; **2**, suprapineal recess. The left medial posterior choroidal artery has been partly removed (**3**) to show with more detail the lateral pineal vein: **4**, left lateral pineal vein and its: **5**, inferior branch and **6**, superior branch draining (**6'**) the blood of the habenular trigone (**5'**) and (**6"**) the choroid plexuses of the suprapineal recess (**2**). **7**, Right lateral pineal vein; **8** and **8'**, left and right pineal arteries; **9**, superior colliculus; **10**, right medial posterior choroidal artery

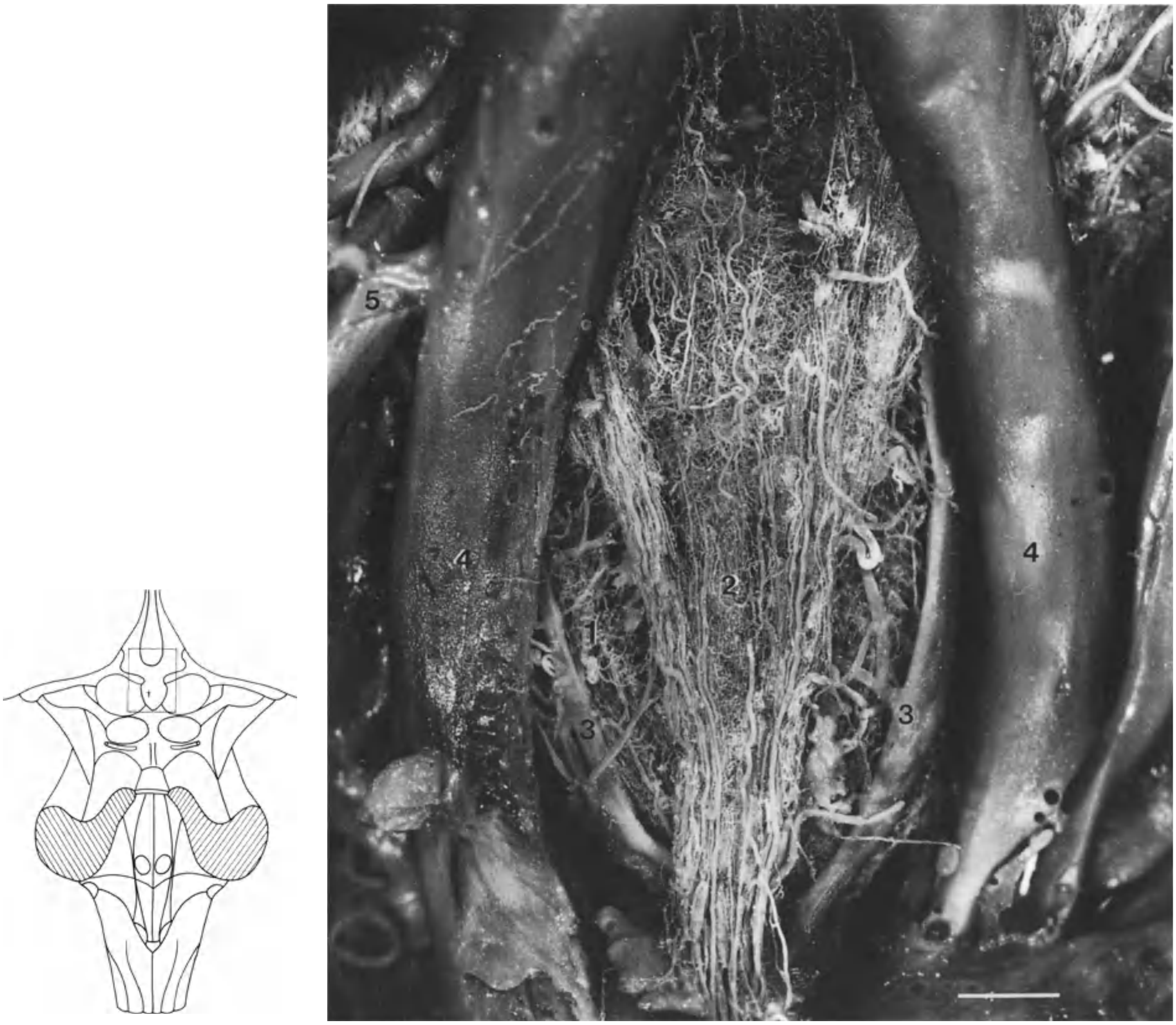


Fig. 83. Superior View of the Pineal Region After Intravascular Resin Injection (Mercox) and Corrosion of the Pineal Tissue. **Bar, 1.8 mm**

The pineal gland (1) is, in this case, covered by a large and highly vascularized suprapineal recess (2). **3**, Lateral pineal veins; **4**, internal cerebral veins; **5**, medial atrial vein (posterior ventricular vein)

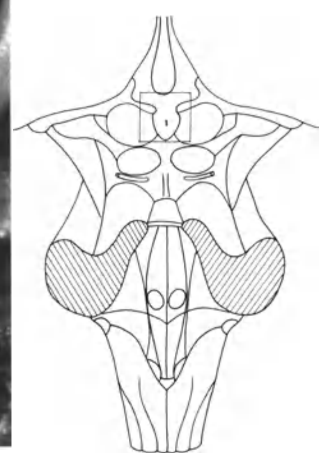


Fig. 84. Superior View of the Pineal Gland After Intravascular Resin Injection (Mercox) and Corrosion of the Pineal Tissue. **Bar, 1.5 mm**

Same preparation as in Fig. 83. The suprapineal recess has been removed. Note the high density of the pineal vascular network (**1**). The pineal gland is surrounded by two concentric venous belts: the internal cerebral veins (**2**) and the lateral pineal veins (**3**). The lateral pineal veins unite posteriorly into a single trunk (**4**), the median pineal vein, reaching the great cerebral vein (see Fig. 80)

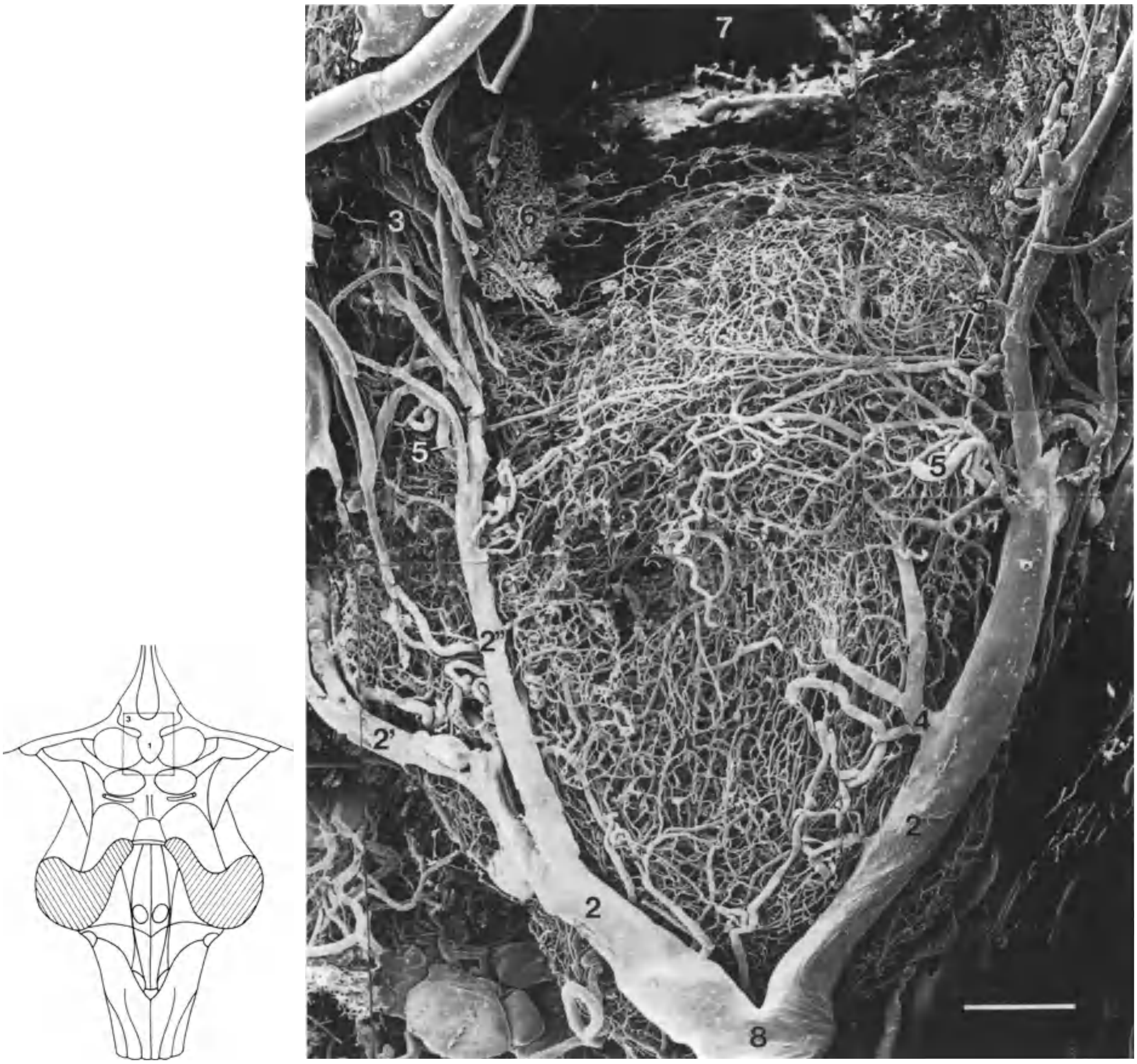


Fig. 85. Superior View of the Pineal Gland. Intravascular Resin Injection (Mercox) and Scanning Electron Microscope View After Corrosion (same preparation as in Fig. 84)
Bar, 1 mm

1, Fine and dense vascular pineal network; **2**, lateral pineal veins, **2'** inferior branch, **2''** superior branch draining the region of the habenular trigone (**3**). **4**, Venous drainage of the pineal gland into the lateral pineal veins; **5**, arterial supply; **6**, choroid plexuses of the third ventricle (**7**). The left and right lateral pineal veins (**2**) join into a median pineal vein (**8**). (Tamaki et al. 1973 described inferior pineal veins joining the median pineal vein). The internal cerebral veins have been removed

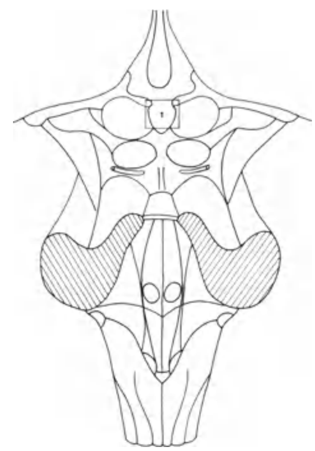


Fig. 86. Superior View of the Pineal Gland After Intravascular Resin Injection (Mercox) and Scanning Electron Microscope View After Corrosion. (Same preparation as in Fig. 85)
Bar, 0.62 mm

A vast cystic cavity in the pineal gland (see Fig. 175) has been opened by removal of the superior part of the gland. Note the vessels of the floor of this cavity with their longitudinal path (1)

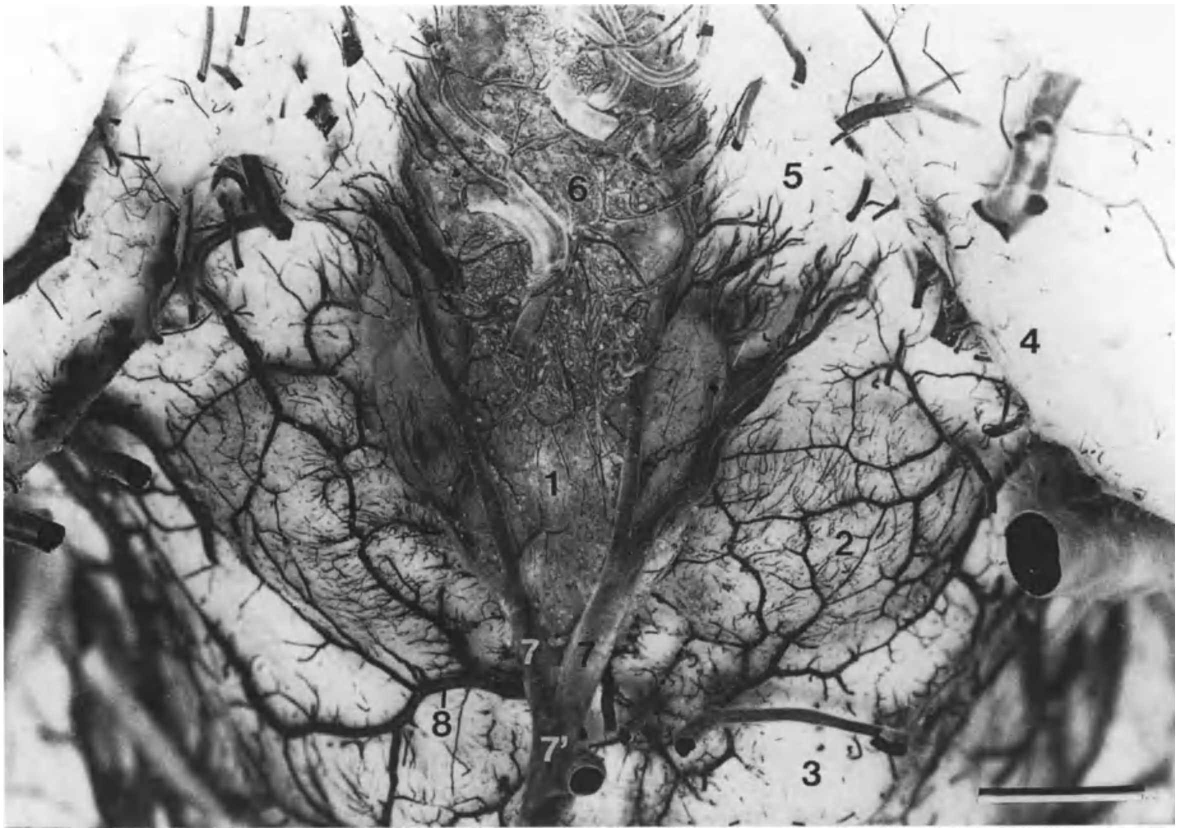
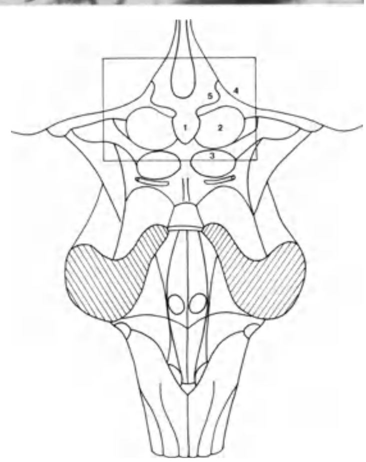


Fig. 87. Overall View of the Venous Network of the Pineal and Collicular Region After Removal of the Arterial Network
Bar, 3.6 mm



1, Pineal gland; **2**, superior colliculus; **3**, inferior colliculus; **4**, pulvinar; **5**, habenular trigone; **6**, suprapineal recess; **7**, right and left lateral pineal veins. The two lateral pineal veins flow into a single trunk, the median pineal vein (**7'**) reaching the great cerebral vein (see Fig. 80). **8**, Intercollicular vein

Figures 88–93 show the arteries and veins of the collicular region.

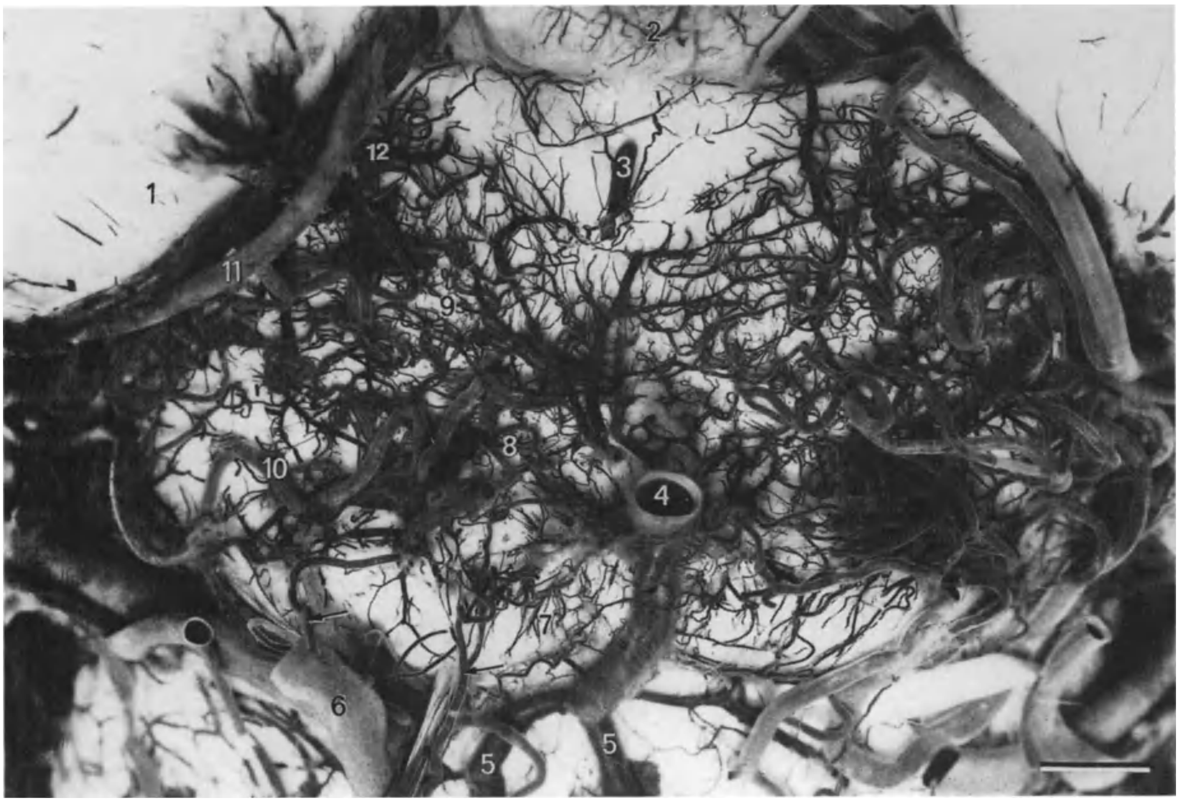
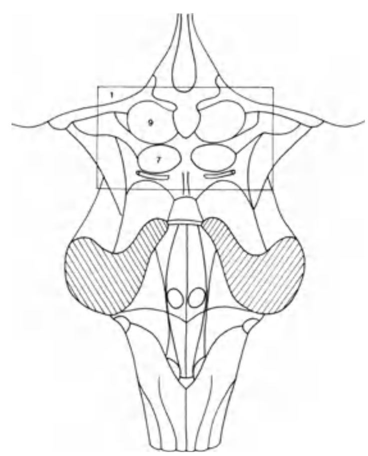


Fig. 88. Posterior View of the Collicular Region Showing the General Arrangement of Arteries and Veins. Note the dense anastomotic arterial network covering the pretectal area (12), the superior colliculus (9) and the upper part of the inferior colliculus (7). **Bar, 3.3 mm**



1, Pulvinar; **2**, pineal gland (displaced upwards); **3**, superior median collicular vein; **4**, precentral vein; **5**, veins of the brachia conjunctiva (veins of the superior cerebellar peduncles); **6**, medial superior cerebellar arteries and their branches supplying the inferior colliculus (*arrows*); **7**, inferior colliculus; **8**, transverse intercollicular sulcus; **9**, superior colliculus; **10**, collicular artery with a single terminal branch; **11**, medial posterior choroidal artery; **12**, pretectal area. The great cerebral and the internal cerebral veins have been removed

Fig. 89. Posterior View of the Collicular Region (right side)
Bar, 3.3 mm

1, Pineal gland; **2**, basal vein; **3**, suprapineal recess; **4**, habenular trigone; **5**, pretectal area; **6**, pulvinar; **7** and **8**, medial posterior choroidal artery; **9**, superior colliculus; **10**, collicular artery and its terminal branches (**10′**, **10″**); **11**, inferior colliculus; **12**, right intercollicular vein; **13**, veins of brachia conjunctiva (veins of the superior cerebellar peduncles); **14**, superior median collicular vein. The *arrows* indicate the numerous posterior branches of the medial posterior choroidal artery

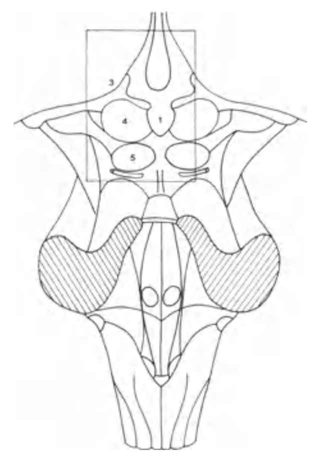


Fig. 90. Posterior View of the Collicular Region (left side)
Bar, 3 mm

1, Pineal gland; **2**, suprapineal recess; **3**, pulvinar; **4**, superior colliculus; **5**, inferior colliculus; **6**, medial posterior choroidal artery and its ramifications; **7**, collicular artery; **8**, superior terminal branch of the collicular artery; **9**, inferior terminal branch; **10**, medial superior cerebellar artery. The great cerebral vein and the internal cerebral veins have been removed

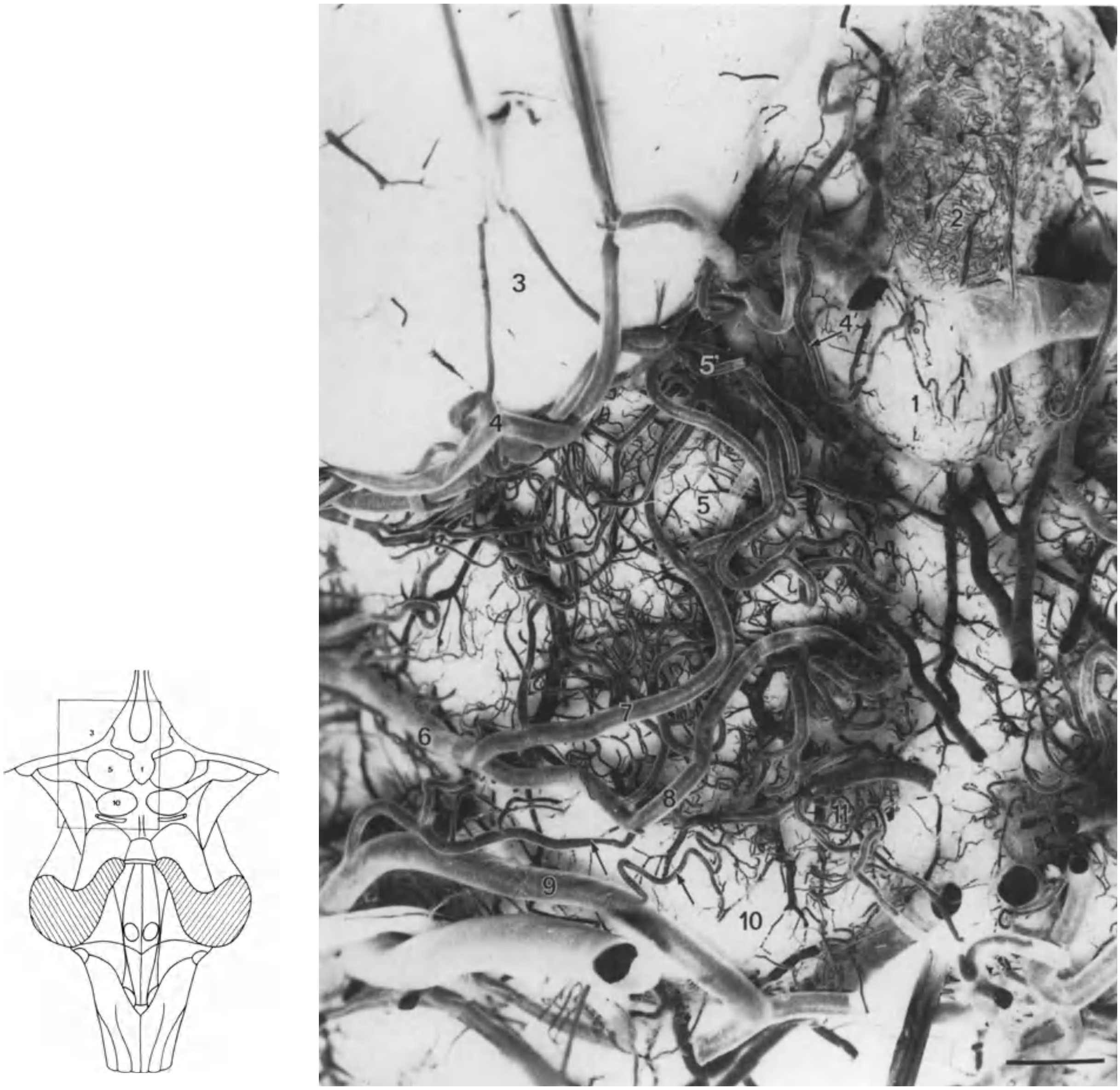


Fig. 91. Posterior View of the Collicular Region (left side) (Same preparation as in Fig. 90) **Bar, 2.8 mm**

1, Pineal gland; **2**, suprapineal recess; **3**, pulvinar. **4**, The medial posterior choroidal artery has been displaced upward to show with more details the arterial network of the colliculi and the ramification of the collicular artery. **4′**, Pineal artery; **5**, arterial network of the superior colliculus; **5′**, arterial network of the pretectal area; **6**, collicular artery; **7**, superior terminal branch of the collicular artery; **8**, inferior terminal branch; **9**, medial superior cerebellar artery and its rami supplying the inferior colliculus (*arrows*). **10**, The lower part of the inferior colliculus has no superficial vessels (see p. 53). **11**, Arterial network of the upper part of the inferior colliculus. The laterodorsal segment of the basal vein has been removed

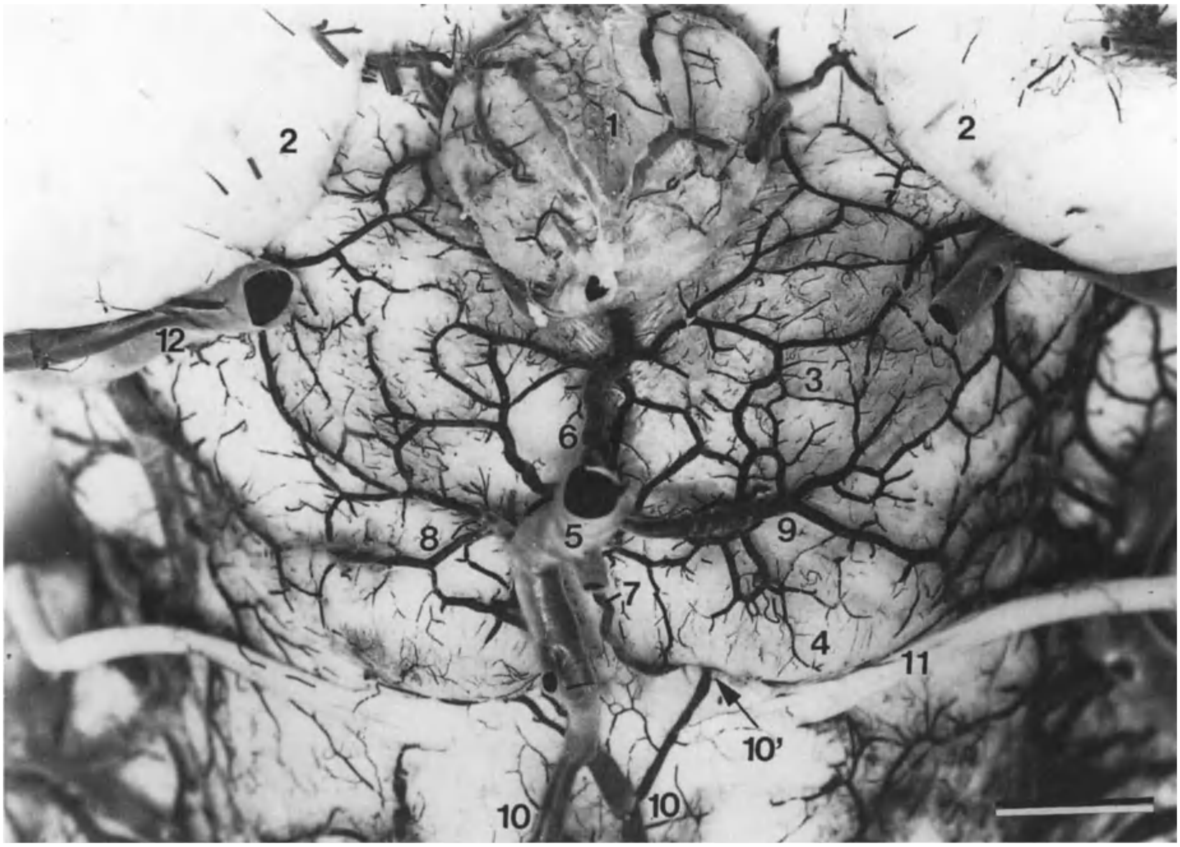
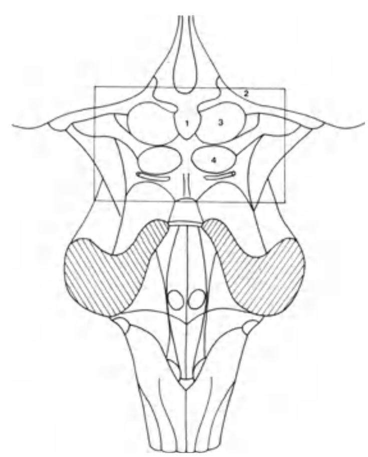


Fig. 92. Posterior View of the Collicular Region After Removal of the Great Cerebral Vein, the Basal Vein and the Arteries, to Show the Fine Venous Network of the Colliculi. (See DUVERNOY 1975 for more details.) **Bar, 4 mm**



1, Pineal gland; **2**, pulvinar; **3**, superior colliculus; **4**, inferior colliculus; **5**, precentral vein. The collicular veins situated in the sulci between the colliculi have a crosswise aspect: **6**, superior median collicular vein; **7**, inferior median collicular vein; **8**, left intercollicular vein; **9**, right intercollicular vein. **10**, The veins of the brachia conjunctiva (veins of the superior cerebellar peduncles) join together to form the precentral vein (**5**); **10'**, vein of the infracollicular recess (see p. 41); **11**, trochlear nerve; **12**, basal vein

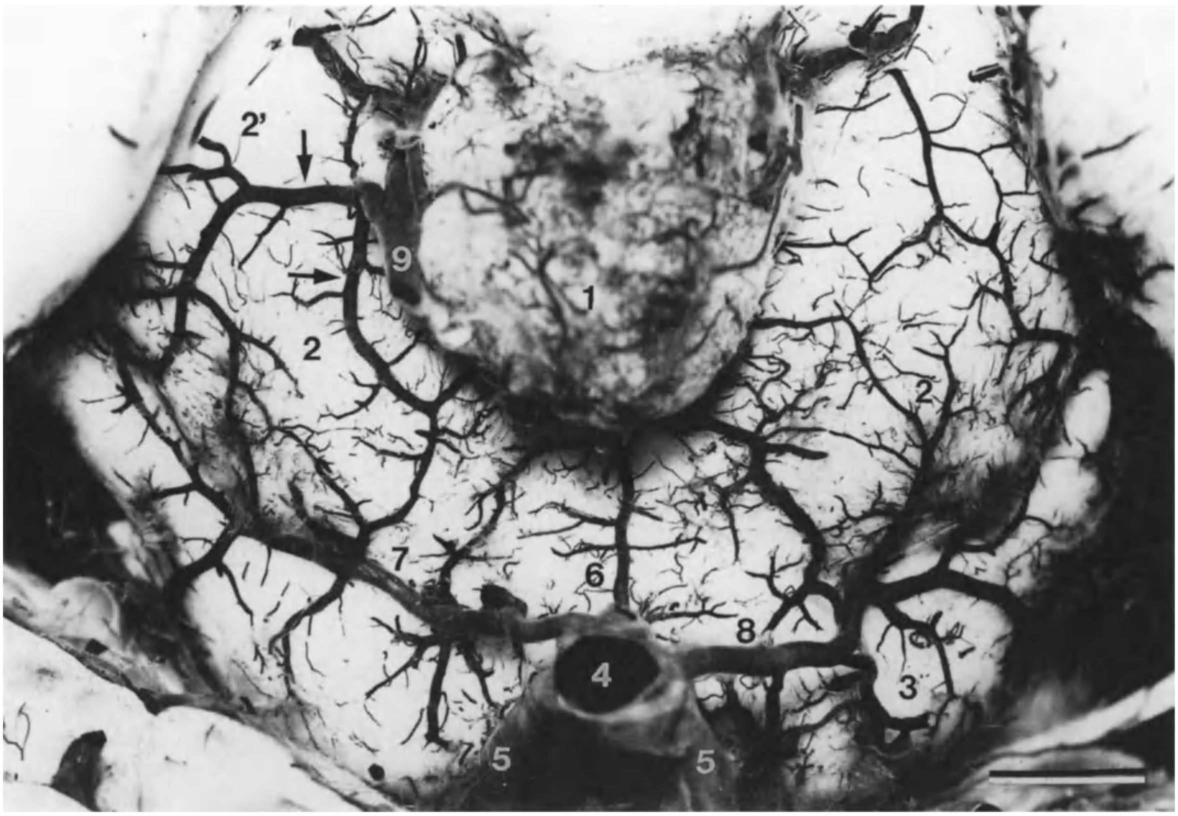
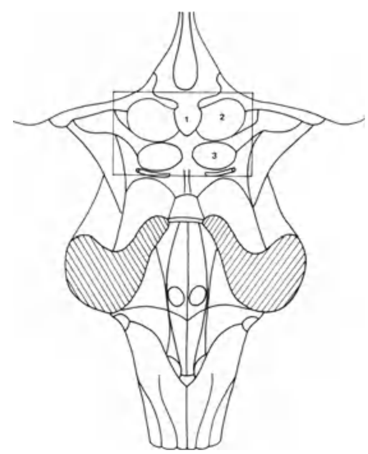


Fig. 93. Posterior View of the Collicular Region After Removal of the Great Cerebral Vein, the Basal Vein and the Arterial Network. **Bar, 3.2 mm**



1, Pineal gland; **2**, superior colliculus; **2'**, pretectal area; **3**, inferior colliculus; **4**, precentral vein composed of the junction of the right and left veins of the brachia conjunctiva (**5**); **6**, superior median collicular vein; **7**, left intercollicular vein; **8**, right intercollicular vein; **9**, lateral pineal vein. Its inferior branch receives some veins of the superior colliculus (**2**) (*arrows*) and pretectal area (**2'**)

PART II

The Vascular Architecture of the Brain Stem

A. Introduction

Investigation of vascular networks in the brain was given great impetus by the work of Pfeifer (1928, 1930), but few workers have undertaken study of the vascular network of the brain stem in man, doubtless because of the technical difficulty involved.

In this study, the vascular architecture of the brain stem has been investigated by using thick sections (300 µm) after injecting the vessels of the brain with a solution of india ink according to the technique described on p. 3. As far as angio-architecture is concerned, this technique yields very irregular results and entails a large series of injections. Vascular ruptures occur frequently during injections of the brain stem, especially in the ventral part of the pons and in the mesencephalon. As a result, the sections illustrated in this atlas are from many different brain stems. Nevertheless, in spite of these difficulties, the technique of injection with india ink appears to provide better results than does the benzidine technique, which stains red blood cells and has been used by many workers.

Identification of nuclei and tracts was controlled by comparing thin sections stained by Bodian's methods with the adjacent thick sections.

Olszewski and Baxter (1954) and Duvernoy (1995) have been followed systematically for the position and nomenclature of nuclei. The atlases of Riley (1943) and De Armond et al. (1974), Afshar et al. (1978), Seeger (1978), Bogerts (1981), Fix and Punte (1981), Nieuwenhuys et al. (1988), Paxinos (1990), and Duvernoy (1999), as well as the work of Mitchell and Warwick (1955) for the motor nucleus of the vagus nerve, the work of Warwick (1953) on the nuclei of the oculomotor nerves, the work of Sadjadpour and Brodal (1968) on the vestibular nuclei, and that of Braak (1970 a, 1970 b, 1972) on the nuclei of the raphe, the inferior olive and the nucleus of the vagus nerve, have all proved useful.

As in the reports of many other authors, whose works will be mentioned later, estimates of the vascular density of the different nuclei and tracts have been attempted in this study. Measurement of the average calibre of the capillaries of the brain stem appears to be an unsound method, judging by the great variations in results obtained by different workers (from 4 to 12 µm). However, for the purposes of this study, the average calibre of capillaries in different regions of the brain stem was estimated using enlargements of the photographs in this atlas. The results obtained did not appear significant, and only some of the more striking variations in calibre are mentioned.

Estimation of the density of capillary networks appears to be of much greater interest. Several workers have used Craigie's (1920, 1933, 1938, 1940) technique of measuring the total length of the capillaries in a cubic millimetre of nervous tissue. In this study, estimation of the density of the vascular network by a simpler method using the Zeiss 'microvideomat' was fortunately available. This technique computes the surface occupied by the vessels relative to a selected area. The results appear at the end of this part (p. 150). Caution must be exercised in interpreting these figures because of the numerous sources of error, such as incomplete filling of vessels, post mortem modifications of calibre, individual differences (Craigie 1920) and possible pathological conditions as mentioned by Campbell et al. (1938). Nevertheless, it was possible to classify nuclei into three groups according to the density of their capillary networks: high, medium and low.

The vascular networks of the medulla, the pons and the mesencephalon will be described in that order.

B. Vascular Architecture of the Medulla
(Figs. 96–123)

I. White Matter

The white matter can be considered as two bands situated medially and laterally in relation to the grey matter in each half of the medulla (Figs. 101, 102 and 103).

The medially situated band of white matter includes the medial lemniscus, the medial longitudinal fasciculus and the corticospinal tract. As KHAN (1969) noted, the vascularization of the lemniscus is denser than that of the corticospinal tract. This is perhaps due to the numerous branches of the anteromedial vessels which cross the lemniscus on their path towards the neighbouring central region. The transverse disposition of the vessels in the lemniscus contrasts with the longitudinal disposition of the thin capillaries of the corticospinal tract (FAZIO and FERRARIS 1949) (Figs. 98 and 102). Where the left and right corticospinal tracts decussate, the vessels follow the same oblique direction as the nerve fibres (Fig. 119).

The lateral band of white matter consists, on each side, of the inferior cerebellar peduncle, the spinal trigeminal tract and the spinothalamic tract. The low vascular density of the inferior cerebellar peduncle can be seen to be similar to that of the corticospinal tract.

II. Grey Matter

The grey matter of the medulla, situated between lateral and medial bands of white matter, can be divided into three zones, according to the differences in their vascular networks, as follows: posterior or periventricular zone, middle or central zone and anterior or olivary zone (Figs. 101 and 102).

a) Posterior Zone

The vascular architecture of the posterior zone is very different in the superior and inferior parts of the medulla.

In the inferior or „closed“ part of the medulla, below the level of the fourth ventricle, the posterior zone is mainly occupied by the large gracile and cuneate nuclei, which have an important vascular network (Figs. 98 and 99). The accessory cuneate nucleus displays particularly dense vascularization being, with the inferior olive, the only nucleus in the medulla to belong to the high density group of nuclei of the brain stem (Figs. 101 and 107). In this part of the medulla, it is difficult to identify the vascular networks of the dorsal motor vagal nucleus and the nucleus of the solitary tracts which adjoin the central canal (Fig. 99).

In the superior or „open“ part of the medulla, the floor of the fourth ventricle forms the posterior zone. The hypoglossal nucleus (situated medially), the nucleus intercalatus, the dorsal motor vagal nucleus, the nucleus of the solitary tract and the medial vestibular nucleus can be clearly seen (Fig. 101). Together, these nuclei form a densely vascularized subependymal mass. The general aspect is that of a triangle, the base situated laterally and the vertex medially (Figs. 101, 102, 103). The vessels of the nucleus intercalatus and especially those of the dorsal motor vagal nucleus have a characteristic longitudinal disposition. The fine calibre of their capillaries is very different from that of the other nuclei (Figs. 106 and 120). The nucleus of the solitary tract can be divided according to its vascular network into two zones. As BRAAK (1972) noted, the term „nucleus of the solitary tract“ has been used only for the nucleus around this tractus, the term „nucleus pigmentosus nervi vagi“ (dorsal visceral grey) and nucleus gelatinosus being used for the part situated under the floor of the fourth ventricle and characterized by the small number of thick capillaries (Figs. 101, 106, 107, 108 and 109).

The superior part of the nucleus of the solitary tract (nucleus ovalis, OLSZEWSKI and BAXTER 1954) is visible in sections of the upper medulla; it is anterior to the vestibular nuclei (Figs. 104 and 105).

b) The Middle or Central Zone

The middle or central zone corresponds to the reticular formation whose main part is the nucleus reticularis medullae oblongatae centralis. The appearance of the vascular network does not permit identification of the secondary nuclei except for the nucleus reticularis lateralis with its clearly denser vascularization (Figs. 99, 100, 101). It will be seen that the nucleus ambiguus can rarely be distinguished because it contains few neurons (TOMASCH and EBNESSAIJADE 1961) and thus has no characteristic vascular density (Figs. 101 and 102). This is contrary to the findings of LIERSE and HORSTMANN (1965) who consider it to be one of the more densely vascularized nuclei of the medulla. The lateral side of the middle or central zone is bounded by the spinal trigeminal nucleus with its dense and easily identified network (Figs. 101, 102, 103, 104, 105).

c) The Anterior Zone

The anterior zone is composed of the inferior olivary nucleus and the medial and dorsal accessory olivary nuclei (Figs. 101, 102, 103, 115, 116, 117, 118, 119). These three nuclei have a characteristic vascularization in the number and size of their capillaries. The inferior olivary nucleus can thus be considered to belong to the high density group of brain stem nuclei.

Several nuclei are outside the three zones previously described. These are the nuclei of the raphé with the characteristically large calibre of their capillaries (Figs. 102, 103, 104), the arcuate nucleus (Figs. 104 and 105) and especially the dorsal and ventral cochlear nuclei adjoining the inferior peduncle. Craigie (1938) describes the particularly dense vascularization of the dorsal cochlear nucleus in the rat; the present observations did not indicate a particularly dense vascularization in man and the small calibre of its vessels was notable (Figs. 104 and 111). It is to be noted, however, that Lierse and Horstmann (1965) have observed in man a vascular network comparable in density to that described in the rat by Craigie (1920). The ventral cochlear nucleus was slightly less densely vascularized than the dorsal nucleus (Figs. 105 and 112) in the material of this study.

C. Vascular Architecture of the Pons

(Figs. 124–145)

The pons can be divided into two parts (Fig. 2c) according to differences in their vascular architecture: a ventral or basilar part and a dorsal part or pontine tegmentum. Close to the junction between these two zones (but in the dorsal zone) are the transversely arranged medial lemnisci, clearly less densely vascularized (Figs. 126–129).

In the ventral part, the pontine corticospinal tract is divided into small secondary bundles; its capillary network seems more densely vascularized than the medullary corticospinal tract. The vascularization of the medial lemniscus and of the pontine corticospinal tract is very similar. The outstanding feature of the ventral part is the exceptionally dense vascularization of the pontine nuclei (Figs. 127, 128, 129, 137, 138 and 143). This region can be included in the high density group of brain stem nuclei.

In the pontine tegmentum the vascular architecture can be contrasted in its superior and inferior levels.

At the inferior level, the pontine tegmentum contains several densely vascularized nuclei. Three are to be classified in the high density group: the large abducent nucleus (Figs. 125, 126, 132), the principal sensory trigeminal nucleus, also notable for the large diameter of its capillaries (Figs. 127, 133) and especially the superior olivary nucleus (Figs. 125, 131), the vascularization of which is almost identical with that of the lateral geniculate body, the most densely vascularized nucleus in the brain stem. The motor trigeminal nucleus (Figs. 128, 133), the superior and lateral vestibular nuclei (Figs. 126, 127) and the facial nucleus (Figs. 124, 125, 131) are less densely vascularized but nevertheless distinct.

At the superior level, the pontine tegmentum contains few densely vascularized nuclei. The small nucleus of the lateral lemniscus, the continuation of the superior olive, is identifiable; the density of its vascularization is similar to that of the olive (Figs. 127–130, 133, 134). The nucleus coeruleus is identified more by its pigmented cells and the large veins running across it (Figs. 129, 130, 134–136, 140, 141, 142) than by the density of its capillary network. It is surprising that Finley and Cobb (1940) should describe this nucleus in the monkey as one of the most densely vascularized regions in the brain stem.

The vascularization of the oral and caudal pontine reticular nuclei and of the nuclei of the raphé places them in the medium density group. The dorsal tegmental nucleus (nucleus compactus suprafascicularis) is clearly visible; it is immediately next to the medial longitudinal fasciculus (Figs. 134, 135).

Most of the pontine tegmentum is occupied at this level by white matter (Figs. 130, 134); the superior cerebellar peduncle is distinguished by the low density of its vascularization and the small calibre of its capillaries; the vascularization of the medial longitudinal fasciculus is twice that of the superior cerebellar peduncle.

The central tegmental tract is often difficult to distinguish from the surrounding vascular network of the pontine reticular nuclei, its capillary network being only slightly less dense (Fig. 134). One distinguishing feature is the small diameter of its capillaries. The mesencephalic trigeminal tract is also identifiable near the nucleus of the locus coeruleus. The mesencephalic trigeminal nucleus cannot be identified with any precision since it contains few neurons and has no characteristic vascular architecture (Figs. 134, 135, 136).

D. Vascular Architecture of the Mesencephalon
(Figs. 146–177)

The majority of highly vascularized nuclei are in the mesencephalon. The capillary networks of the three zones of the mesencephalon, the tectum, tegmentum and crus cerebri (see Fig. 2d) will be described in this order.

I. Vascular Architecture of the Tectum of the Mesencephalon (Colliculi)

The inferior colliculus can be immediately identified as one of the most densely vascularized regions of the brain stem (Figs. 146, 156, 165, 166, 176); this fact, which was noted by KHAN (1969), was not supported by the findings of LIERSE and HORSTMANN (1965) who considered the vascular density of the inferior colliculus to be less than that of the hypoglossal nucleus. The vascular density of the superior colliculus is one third that of the inferior colliculus. The vascular arrangement of this nucleus is so regular in appearance that it is impossible to distinguish in vascular terms the different layers of nerve cells of which it is made up (Figs. 148, 149, 157, 165, 166). It is usually possible to distinguish the mesencephalic trigeminal tract, a narrow, poorly vascularized band between the superior colliculus and the periaqueductal grey matter (Figs. 157, 176). On the lateral edge of the colliculus, the densely vascularized nucleus intracuneiformis (OLSZEWSKI and BAXTER 1954) is clearly visible (Figs. 149, 157).

II. Vascular Architecture of the Tegmentum of the Mesencephalon

In this intermediate region of the mesencephalon, numerous nuclei and tracts can be distinguished by their capillary networks. Based on such criteria, it is possible to divide the tegmentum into two levels, superior and inferior.

At the inferior tegmental level, the main features are the densely vascularized network of the trochlear and oculomotor nuclei and of the substantia nigra. The trochlear nucleus is thus rendered clearly visible (Figs. 146, 152, 167, 168). Vascular concentration corresponding to its accessory nucleus is sometimes identifiable inferior to it (PEARSON 1943) (Figs. 136 and 170).The capillary network of the oculomotor nucleus is even denser than that of the trochlear. KHAN (1969) considered its density the most marked in the whole mesencephalon, whereas in the present material, the lateral geniculate body (which is, in fact, a part of the thalamus) and the inferior colliculus were more densely vascularized. At inferior tegmental levels, the main and the caudal central oculomotor nuclei can be distinguished, the latter being less densely vascularized (Figs. 147, 148, 153, 167, 168). The trochlear nucleus and oculomotor nucleus are almost in contact with the dorsal nucleus of the raphé (nucleus supratrochlearis) which is distinguished by the density of its vascularization from the adjacent periaqueductal grey matter (Figs. 146, 147, 152, 153). This grey matter is characterized by its poor vascularization. As KHAN (1969) has shown, it is the least densely vascularized nucleus in the midbrain. The preparations shown here indicate that it is the least densely vascularized nucleus in the whole brain stem (Figs. 147, 148, 149).

The vascularization of the interpeduncular nucleus (and of the surrounding ventral tegmental area) appears in this material to be consistently poor, contrary to the findings of KHAN (1969), who classified it among the nuclei of high vascular density (Fig. 146). At this inferior tegmental level, the substantia nigra is clearly visible and its constituent parts, compact and reticular, can be easily identified (Figs. 148, 149, 158, 160). The previously described method used to estimate the capillary network density does not provide a reading for the compact part because of the presence of pigmented cells, which are indistinguishable from injected capillaries. Nevertheless, it appears that, as several workers have noted (FINLEY 1936; DUNNING and WOLFF 1937; KHAN 1969), the capillary network of the compact part is dense, even more so than that of the reticular part.

At inferior tegmental levels, white matter is clearly defined and is mainly composed of the superior cerebellar peduncles and the medial and lateral lemnisci (Figs. 146, 147). The capillary networks of the peduncles and of the lemnisci are much alike. On the other hand, the medial longitudinal fasciculus is clearly more densely vascularized; but this density is difficult to estimate because of the numerous isolated groups of cells in the fasciculus, which belong to the trochlear and oculomotor nuclei.

At superior tegmental levels, large and densely vascularized nuclei occur. The main oculomotor nucleus is still prominent (Figs. 149, 154, 170); between the left and right main nuclei, the narrow central nucleus (or Perlia) can be seen. Its vascular density is comparable to that of the main nuclei but the accessory oculomotor nucleus (of Edinger-Westphal) is difficult to distinguish (Figs. 149, 154, 167, 168).

The red nucleus is the largest in this region. Its capillary network is especially dense approaching that of the main oculomotor nucleus. It is to be noted that the most densely vascularized region surrounds a poorly vascularized central region forming a crescent whose open aspect is dorsal when seen in transverse section (Figs. 149 and 158). This crescent is too large to be equated with the magnocellular part of the red nucleus which is small in man (STERN 1938). The red nucleus departs from this oval shape superiorly, where the habenulopeduncular tract crosses it (Figs. 150, 151, 159). Its poorly vascularized perimeter sometimes contains small capillary networks which may correspond to the nuclei intracapsulares (Figs. 158).

At superior or cranial tegmental levels of the mesencephalon, the compact part of the substantia nigra gradually disappears, and the area of the poorly vascularized reticular part is correspondingly increased. Thus, the substantia nigra is not so easy to distinguish from neighbouring capillary networks (Fig. 150).

In sections through this superior part of the mesencephalon, several densely vascularized nuclei (not actually situated in the tegmentum) are to be seen and will be described here. A special study deals with the vascular architecture of the pineal gland (Figs. 170–175). The medially situated mamillary bodies (Figs. 150, 164) and more laterally geniculate bodies are also described (Figs. 150, 151, 161, 169). The vascularization of both is very similar, and they can be classified in the high density group.

In its vascularization, the lateral geniculate body is the densest of all the brain stem nuclei. FINLEY and COBB (1940) have noted the particularly high density in this nucleus. The vascular network of the lateral geniculate body has a striated appearance and, especially in coronal sections, it is possible to distinguish the six layers typical of this nucleus in man (Fig. 169). The exceptionally tortuous path of the capillaries here is to be emphasized.

Finally, one last nucleus, which can be associated with the upper or diencephalic limit of the mesencephalic tegmentum, is the subthalamic nucleus which is continuous with the substantia nigra (Figs. 151 and 162). The vascularization of the subthalamic nucleus is particularly dense and even exceeds that of the substantia nigra although the latter contains more neurons, as noted by FINLEY (1936). FINLEY's division of the subthalamic nucleus into a densely vascularized medial zone and a less densely vascularized lateral zone is not corroborated by these observations.

The white substance at cranial tegmental levels is difficult to distinguish in terms of individual tracts; for example, the lemnisci are not identifiable by their vascular network at such levels.

III. Vascular Architecture of the Crus Cerebri

The crus cerebri is a less densely vascularized region, being entirely composed of nerve fibres, including the corticospinal tract (Figs. 146–151). The drawing of section X, Fig. 33 shows the large number of veins and arteries which run through the crus cerebri to nuclei in the mesencephalon; it is to be noted that these vessels are not prominent in sections, because they are steeply inclined in a cranial direction and therefore only a small segment of each is visible in each section (Figs. 149 and 160).

E. Conclusions

Variations in the density of the vascularization of the nuclei, tracts and fasciculi of the brain stem provide criteria for distinguishing between most of them. In the following table, these entities and the brain stem nuclei have been classified on a scale of increasing vascular density.

The nuclei have been divided into three groups according to whether their vascular density is high, medium or low. CRAIGIE (1920), WOLFF (1938) and LIERSE and HORSTMANN (1965) considered that motor nuclei are less densely vascularized (especially those nuclei with autonomic functions) than sensory nuclei; Table 1 shows numerous exceptions to this concept. Analysis of the list of high density nuclei shows that in man they may be considered to fall into three functional groups:

1. Afferent (especially sensory) nuclei: principal sensory trigeminal nucleus, geniculate bodies, inferior colliculus, superior olivary nucleus, mamillary body
2. Motor (efferent) nuclei of nerves innervating the muscles of the eyeball: oculomotor, trochlear and abducent nuclei
3. Nuclei connected to the neocerebellum: inferior olivary nucleus, red nucleus, pontine nuclei

These three groups of high density nuclei may be considered to be centres of high nervous activity if we accept the theory that the vascular density of a nucleus is not in proportion to the number of neurons but in direct proportion to the number of synapses (WOLFF 1938).

Table 1. List of Tracts and Nuclei of the Brain Stem Classified According to the Increasing Density of their Vascularization

I. Tracts				
Corticospinal tract				
Inferior cerebellar peduncle				
Superior cerebellar peduncle				
Medial lemniscus				
Spinothalamic tract				
Medial longitudinal fasciculus				
Spinal trigeminal tract and central tegmental tract				

II. Nuclei		Medulla	Pons	Mesencephalon
Periaqueductal gray	Low			+
Nucleus intercalatus		+		
Nucleus of the solitary tract		+		
Hypoglossal nucleus	Medium	+		
Accessory oculomotor nucleus				+
Substantia nigra, reticular part				+
Dorsal motor vagal nucleus		+		
Dorsal nucleus of the raphé				+
Oral pontine reticular nucleus			+	
Spinal trigeminal nucleus		+		
Cuneate nucleus		+		
Nucleus gigantocellularis		+		
Motor trigeminal nucleus			+	
Caudal central oculomotor nucleus				+
Medial vestibular nucleus		+		
Dorsal cochlear nucleus		+		
Superior colliculus				+
Arcuate nucleus		+		
Dorsal tegmental nucleus			+	
Nucleus praepositus		+		
Principal sensory trigeminal nucleus	High		+	
Sublingual nucleus		+		
Trochlear nucleus				+
Abducent nucleus			+	
Accessory cuneate nucleus		+		
Inferior olivary nucleus		+		
Medial geniculate body				+
Nucleus intracuneiformis				+
Mamillary body				+
Central oculomotor nucleus				+
Pontine nuclei			+	
Red nucleus				+
Medial accessory olivary nucleus		+		
Subthalamic nucleus				+
Main oculomotor nucleus				+
Inferior colliculus				+
Superior olivary nucleus			+	
Lateral geniculate body				+

Figures 96–105, 124–130 and 146–151 are overall views (after intravascular india ink injections) of transverse (axial) sections of medulla, pons and mesencephalon, respectively, followed by enlargements showing, with more details, the vascular network in relation to the nervous structures. Some coronal and sagittal sections, whose plane levels are indicated on the transverse sections, are added in order to evaluate the longitudinal extension of nuclei and tracts. (For more information about the brain stem structure see DUVERNOY 1995).

Fig. 94. Median (Sagittal) Section Showing the General Aspect of the Internal Brain Stem Blood Vessels. **Bar, 3.7 mm**

1, Medulla; **2**, pons, basilar (ventral) part; **3**, pons, tegmentum; **4**, mesencephalon, decussation of the superior cerebellar peduncles; **5**, medial longitudinal fasciculus; **6**, cerebral acqueduct; **7**, mesencephalic tectum (inferior colliculi); **8**, cerebellum (superior vermis); **9**, fourth ventricle; **10**, note the downward curved aspect of the blood vessels supplying the upper pontine tegmentum and (**11**) the upward curved aspect of those supplying the lower pontine tegmentum (see Fig. 28d). Note also (**12**) the high density of the internal anteromedial vessels originating from the foramen caecum (**12'**)

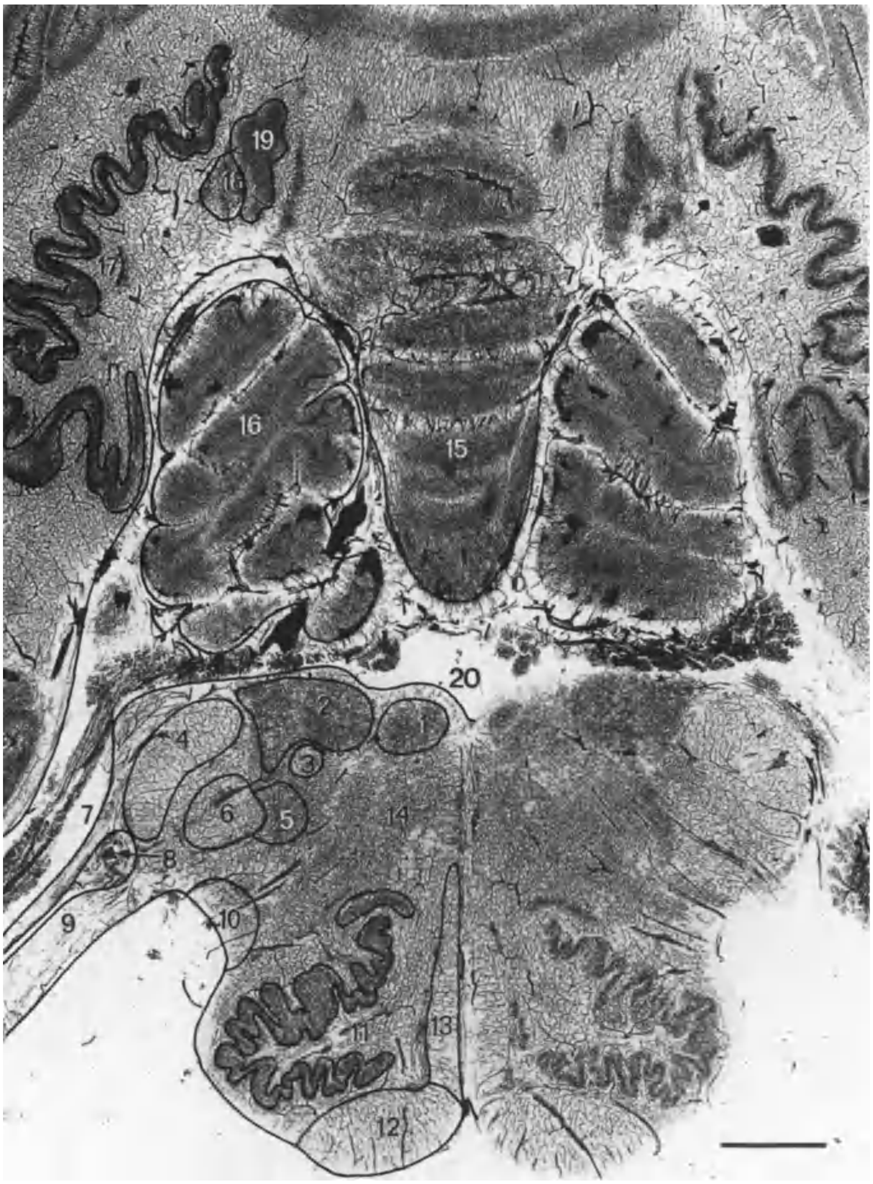


Fig. 95. Transverse Section of the Medulla Oblongata Showing the Relation of Medulla and Cerebellum and their General Vascular Architecture. (Level of superior third of the inferior olive) **Bar, 3.2 mm**

Medulla Oblongata: **1**, hypoglossal nucleus; **2**, medial vestibular nucleus; **3**, solitary tract; **4**, inferior cerebellar peduncle; **5**, spinal trigeminal nucleus; **6**, spinal trigeminal tract; **7**, lateral recess of the fourth ventricle; **8**, lateral medullary vein; **9**, vagus nerve; **10**, spinothalamic tract; **11**, inferior olivary nucleus; **12**, corticospinal tract; **13**, medial lemniscus; **14**, central reticular formation (nucleus reticularis medullae oblongatae centralis)
Cerebellum: **15**, nodulus; **16**, tonsil; **17**, dentate nucleus; **18**, emboliform nucleus; **19**, globose nucleus; **20**, fourth ventricle

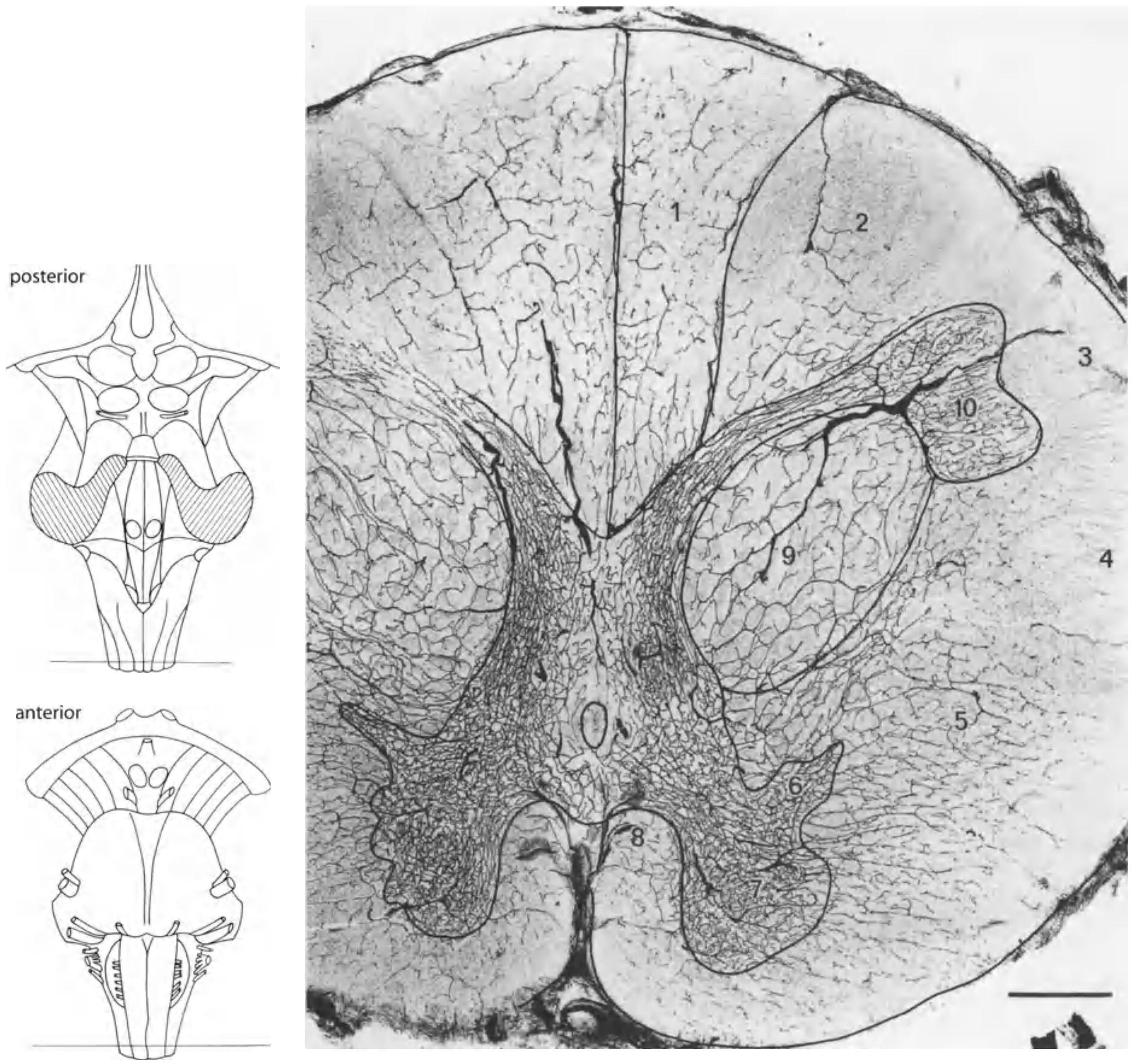


Fig. 96. Transverse Section of the Upper Spinal Cord (caudal to the level of the decussation of pyramids). **Bar, 950 μm**

1, Gracile fasciculus; **2**, cuneate fasciculus; **3**, dorsal spinocerebellar tract; **4**, ventral spinocerebellar tract; **5**, spinothalamic tract; **6**, accessory nucleus; **7**, cranial extremity of nucleus ventromedialis of spinal cord (nucleus supraspinalis); **8**, medial longitudinal fasciculus; **9**, corticospinal tract; **10**, substantia gelatinosa (spinal trigeminal nucleus, subnucleus caudalis)

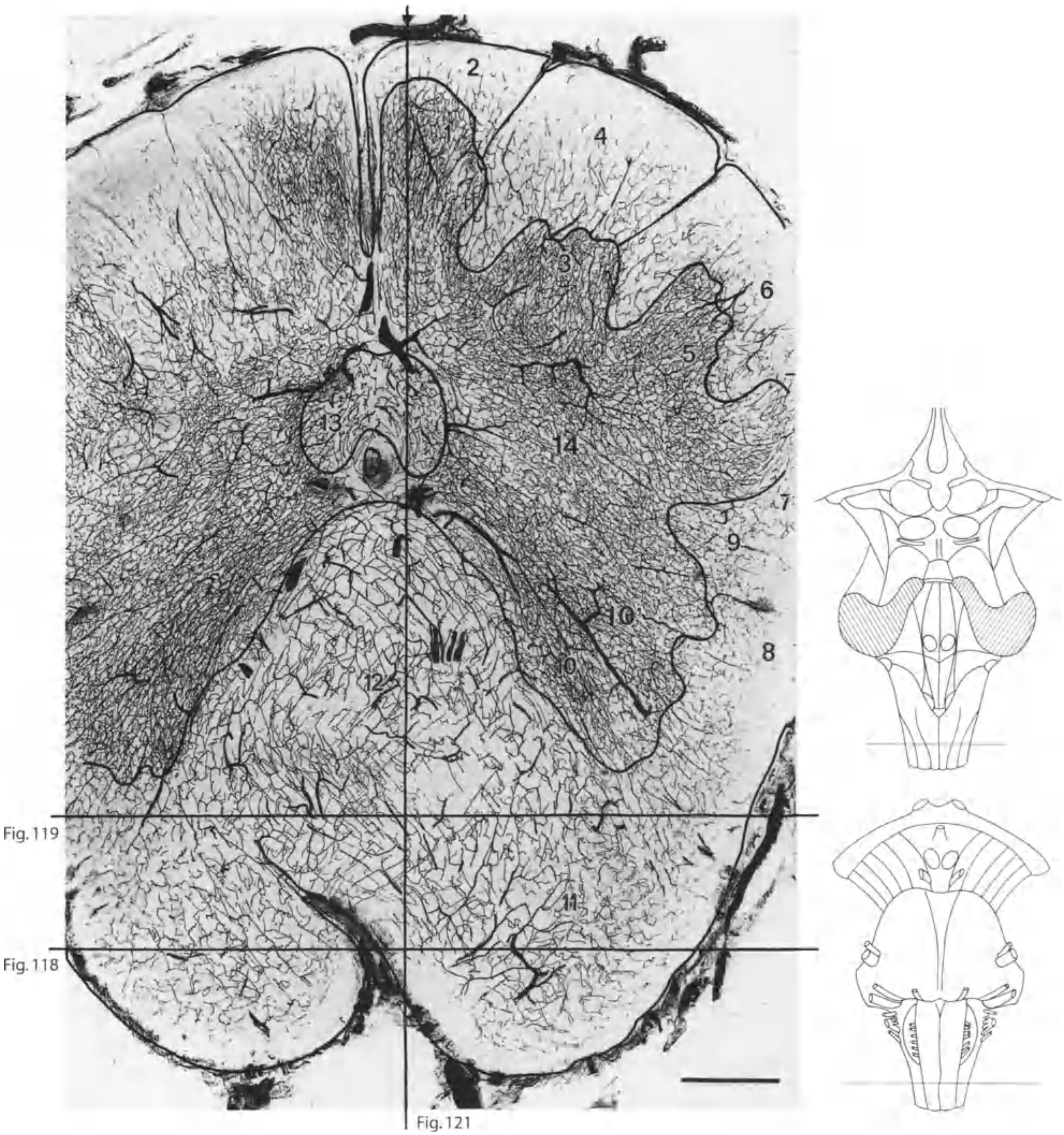


Fig. 97. Transverse Section of the Medulla Oblongata (level of decussation of the pyramids). **Bar, 1.1 mm**

1, Gracile nucleus; **2**, gracile fasciculus; **3**, cuneate nucleus; **4**, cuneate fasciculus; **5**, spinal trigeminal nucleus (subnucleus caudalis); **6**, spinal trigeminal tract; **7**, dorsal spinocerebellar tract; **8**, ventral spinocerebellar tract; **9**, spinothalamic tract; **10**, cranial extremity of nucleus ventromedialis of spinal cord (nucleus supraspinalis); **10'**, accessory nucleus (nucleus ambiguus lowest part); **11**, corticospinal tract; **12**, decussation of the pyramids; **13**, nucleus of the solitary tract; **14**, nucleus reticularis medullae oblongatae centralis
The *lines* represent the planes of Figs. 118, 119 and 121

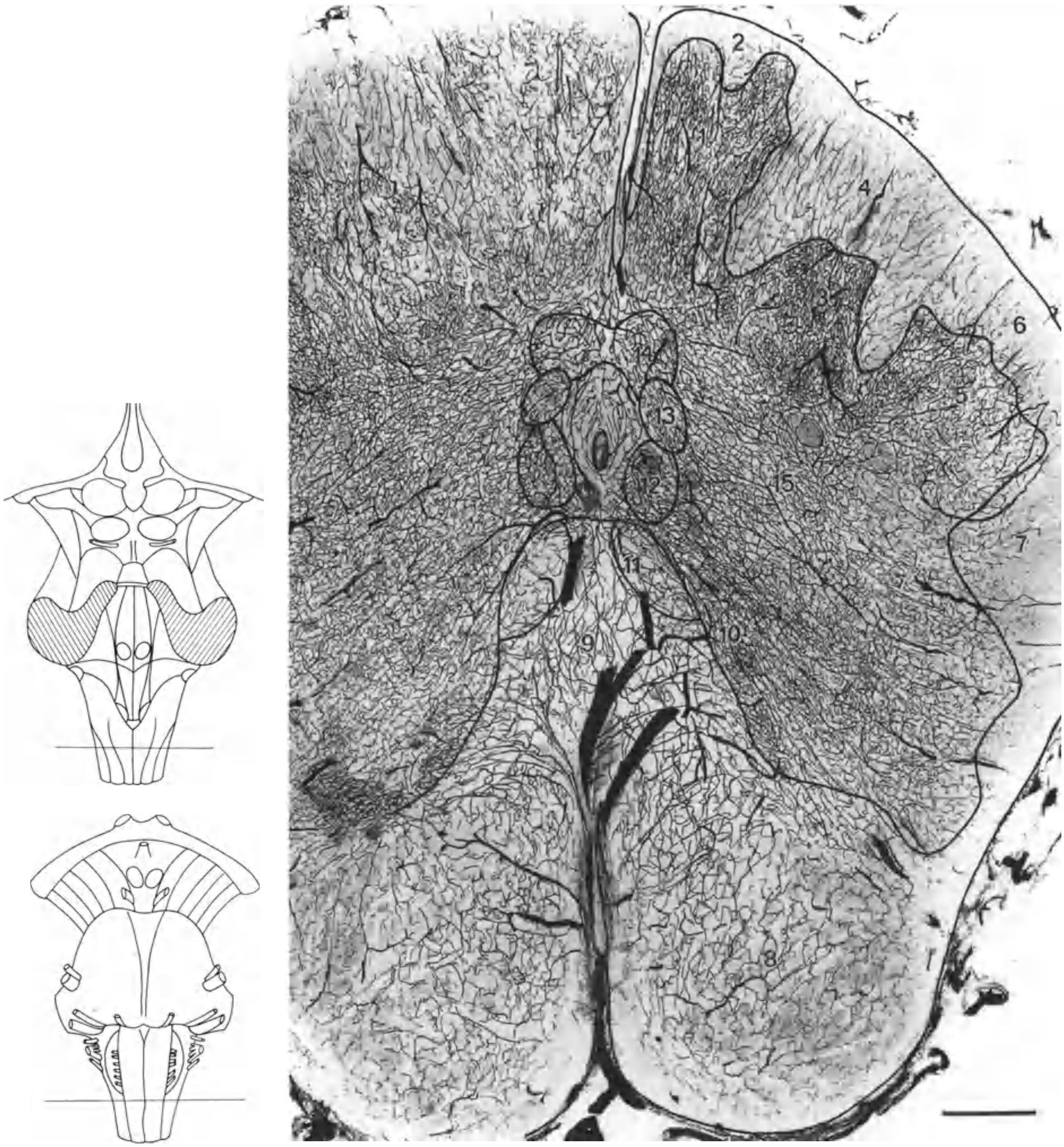


Fig. 98. Transverse Section of the Medulla Oblongata (level of sensory decussation). **Bar, 1.2 mm**

1, Gracile nucleus; **2**, gracile fasciculus; **3**, cuneate nucleus; **4**, cuneate fasciculus; **5**, spinal trigeminal nucleus (subnucleus caudalis); **6**, spinal trigeminal tract; **7**, spinothalamic tract; **8**, corticospinal tract; **9**, decussation of the lemnisci (sensory decussation); **10**, nucleus supraspinalis (see Fig. 97); **11**, medial longitudinal fasciculus; **12**, hypoglossal nucleus; **13**, dorsal motor vagal nucleus; **14**, nucleus of the solitary tract; **15**, nucleus reticularis medullae oblongatae centralis

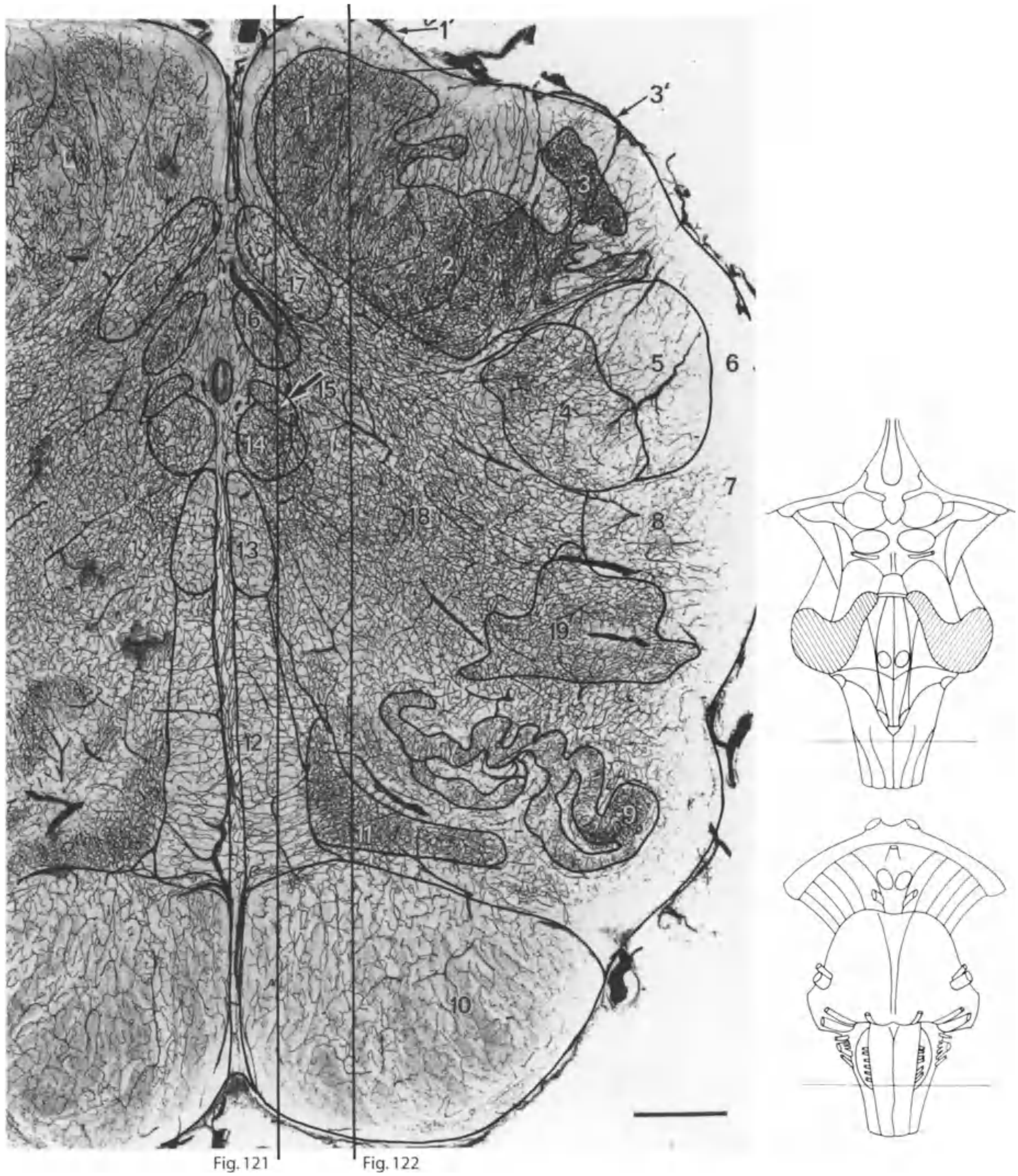
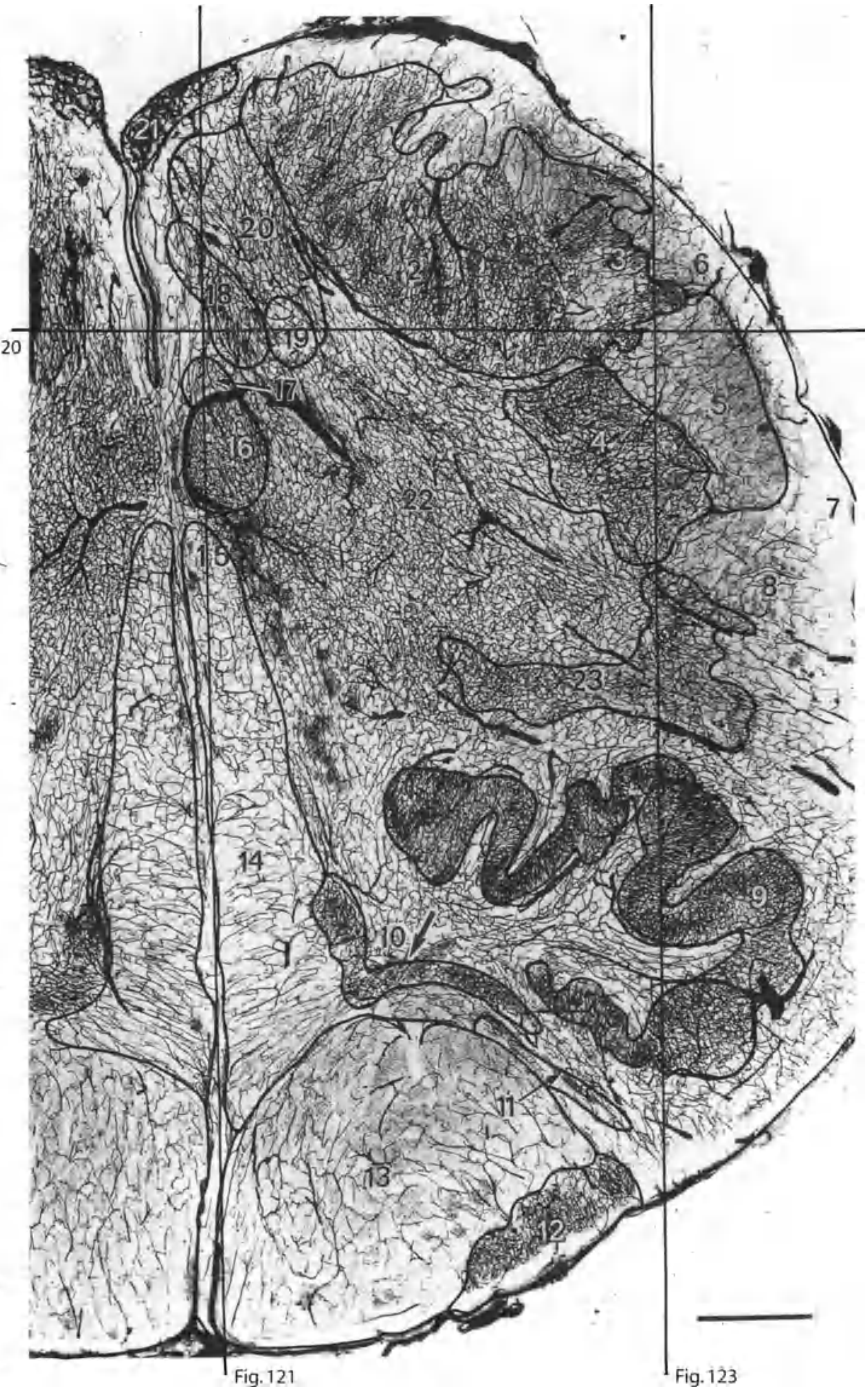
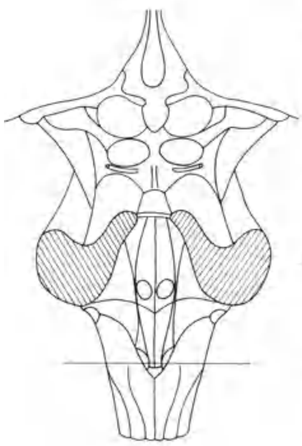


Fig. 99. Transverse Section of the Medulla Oblongata (level of the lower pole of the inferior olive). **Bar, 1.2 mm**

1, Gracile nucleus; **1'**, gracile tubercle (clava); **2**, cuneate nucleus; **3**, accessory cuneate nucleus; **3'**, cuneate tubercle; **4**, spinal trigeminal nucleus (subnucleus caudalis); **5**, spinal trigeminal tract; **6**, dorsal spinocerebellar tract; **7**, ventral spinocerebellar tract; **8**, spinothalamic tract; **9**, inferior olivary nucleus; **10**, corticospinal tract; **11**, medial accessory olivary nucleus; **12**, medial lemniscus; **13**, medial longitudinal fasciculus; **14**, hypoglossal nucleus; **15**, nucleus intercalatus; **16**, dorsal motor vagal nucleus; **17**, nucleus of the solitary tract; **18**, nucleus reticularis medullae oblongatae centralis; **19**, nucleus reticularis lateralis
The *lines* represent the planes of Figs. 121 and 122





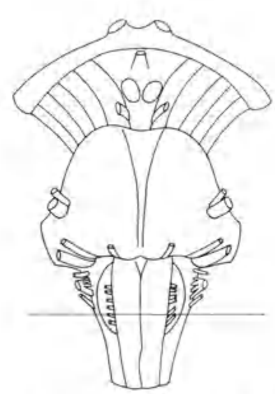


Fig. 100. Transverse Section of the Medulla Oblongata (level of the obex of the fourth ventricle). **Bar, 1.2 mm**

1, Gracile nucleus; **2**, cuneate nucleus; **3**, accessory cuneate nucleus; **4**, spinal trigeminal nucleus (subnucleus interpolaris); **5**, spinal trigeminal tract; **6**, dorsal spinocerebellar tract; **7**, ventral spinocerebellar tract; **8**, spinothalamic tract; **9**, inferior olivary nucleus; **10**, medial accessory olivary nucleus; **11**, arcuate nucleus (nucleus conterminalis); **12**, arcuate nucleus; **13**, corticospinal tract; **14**, medial lemniscus; **15**, medial longitudinal fasciculus; **16**, hypoglossal nucleus; **17**, nucleus intercalatus; **18**, dorsal motor vagal nucleus; **19**, solitary tract; **20**, nucleus of the solitary tract; **21**, area postrema (the area postrema, nucleus of solitary tract and dorsal motor nucleus form together the dorsomedial medulla with autonomic functions) (see Duvernoy 1995); **22**, nucleus reticularis medullae oblongatae centralis; **23**, nucleus reticularis lateralis

The *lines* represent the planes of Figures 120, 121 and 123

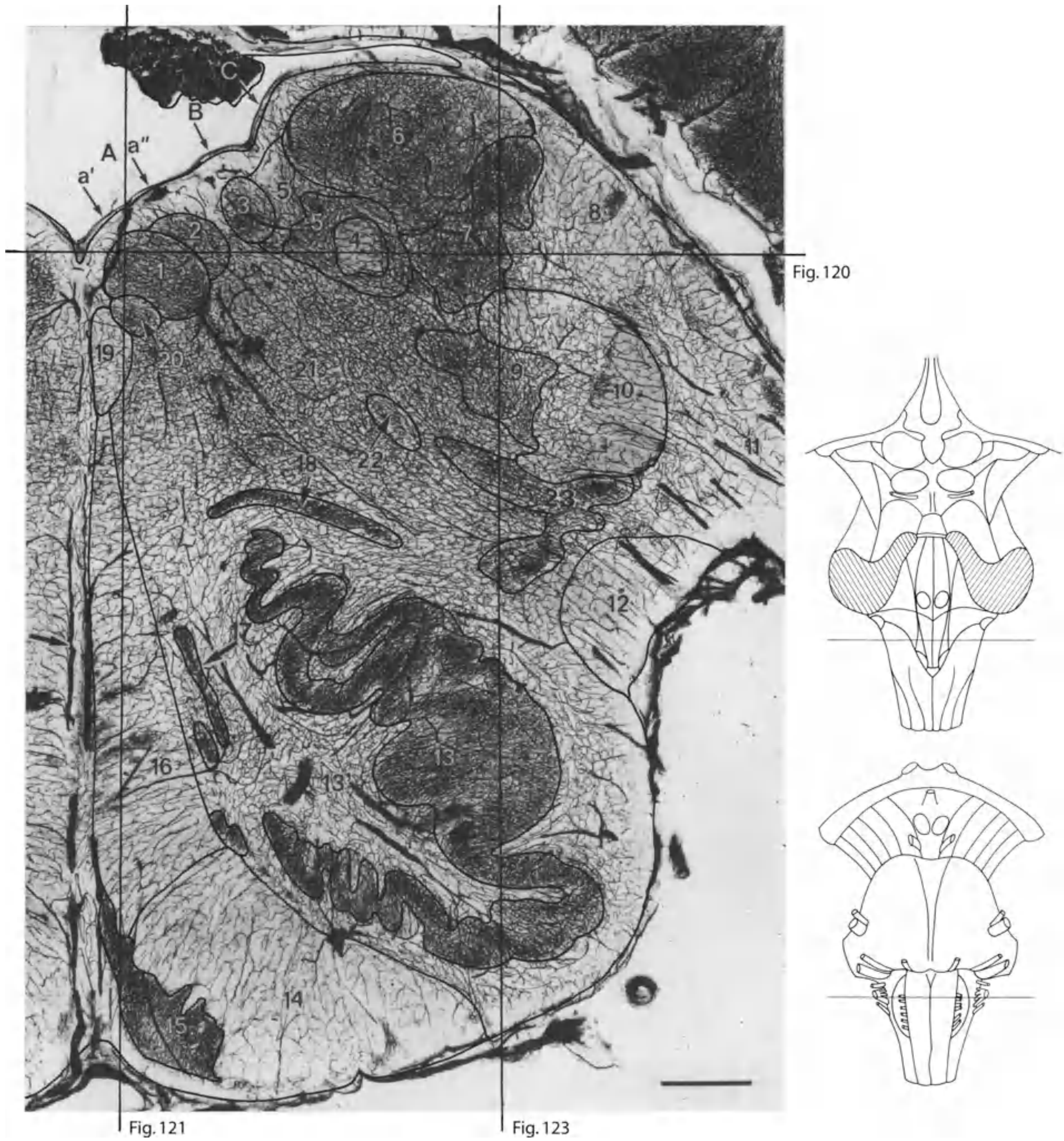


Fig. 101. Transverse Section of the Medulla Oblongata (intermediate olivary level). **Bar, 1.4 mm**

1, Hypoglossal nucleus; **2**, nucleus intercalatus (with the sublingual nucleus, it belongs to the group of perihypoglossal nuclei with unknown functions); **3**, dorsal motor vagal nucleus; **4**, solitary tract; **5**, nucleus of the solitary tract; **5'**, nucleus gelatinosus nervi vagi (belonging to the nucleus of the solitary tract); **6**, medial vestibular nucleus; **7**, accessory cuneate nucleus; **8**, inferior cerebellar peduncle; **9**, spinal trigeminal nucleus (subnucleus interpolaris); **10**, spinal trigeminal tract; **11**, vagus nerve; **12**, spinothalamic tract; **13**, inferior olivary nucleus; **13'**, hilum of the inferior olivary nucleus; **14**, corticospinal tract; **15**, arcuate nucleus; **16**, medial lemniscus; **17**, medial accessory olivary nucleus; **18**, dorsal accessory olivary nucleus; **19**, medial longitudinal fasciculus; **20**, sublingual nucleus (of Roller) (unknown functions); **21**, nucleus reticularis medullae oblongatae centralis; **22**, nucleus ambiguus; **23**, nucleus reticularis lateralis; **A**, hypoglossal trigone; **a'**, area medialis; **a''**, area plumiformis; **B**, vagal trigone; **C**, vestibular area

The *lines* represent planes of Figs. 120, 121 and 123

An *arrow* indicates an internal anteromedial blood vessel

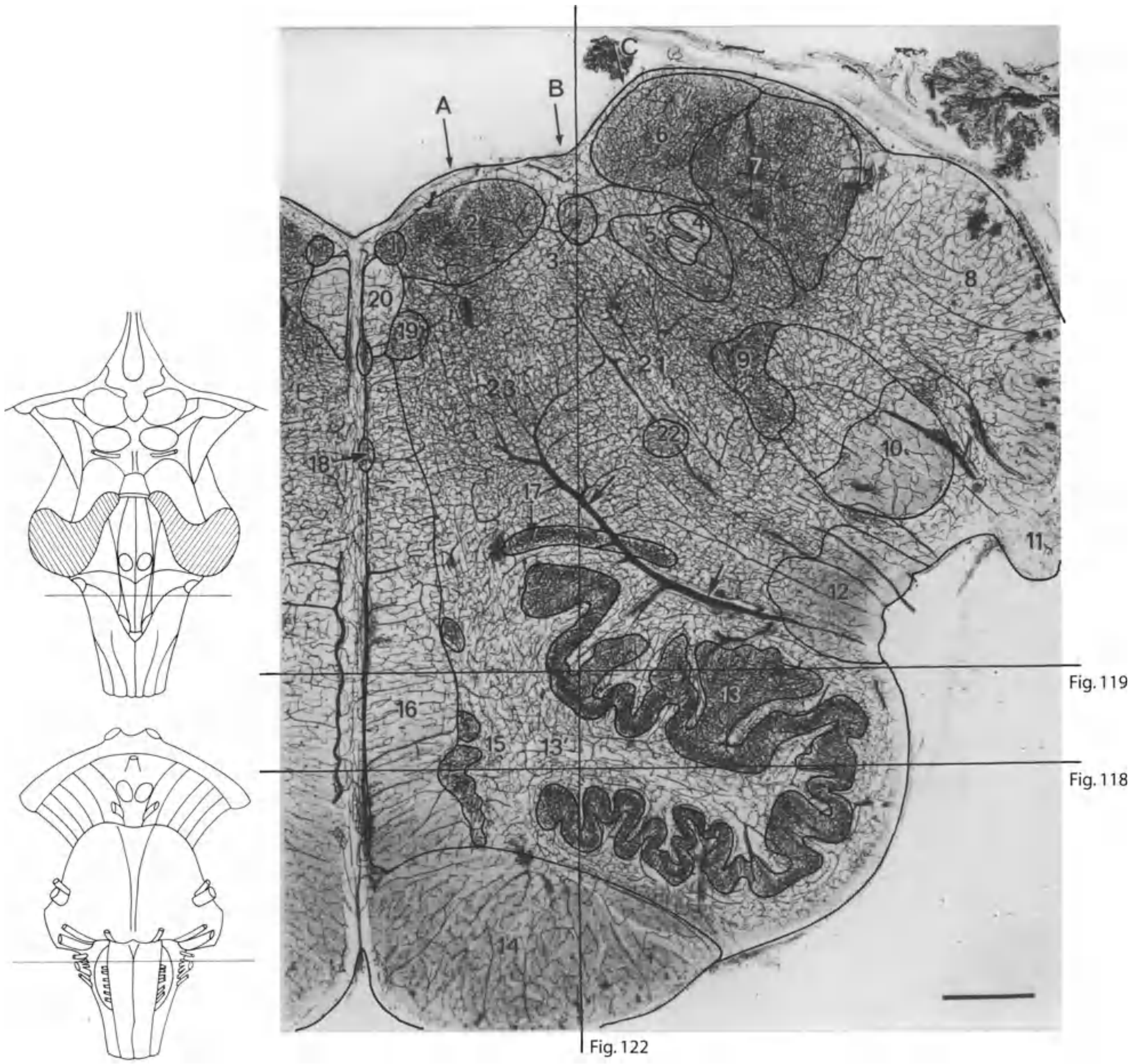


Fig. 102. Transverse Section of the Medulla Oblongata (level between cranial and intermediate thirds of the inferior olive)
Bar, 1.3 mm

1, Paramedian nucleus; **2**, nucleus praepositus (it plays a role in the control of eye movements); **3**, dorsal motor vagal nucleus; **4**, solitary tract; **5**, nucleus of the solitary tract; **6**, medial vestibular nucleus; **7**, accessory cuneate nucleus; **8**, inferior cerebellar peduncle; **9**, spinal trigeminal nucleus (subnucleus interpolaris); **10**, spinal trigeminal tract; **11**, vagus nerve; **12**, spinothalamic tract; **13**, inferior olivary nucleus; **13'**, hilum of the inferior olivary nucleus; **14**, corticospinal tract; **15**, medial accessory olivary nucleus; **16**, medial lemniscus; **17**, dorsal accessory olivary nucleus; **18**, nucleus raphes obscurus; **19**, sublingual nucleus (of Roller); **20**, medial longitudinal fasciculus; **21**, nucleus reticularis medullae oblongatae centralis; **22**, nucleus ambiguus; **23**, nucleus gigantocellularis; **A**, hypoglossal trigone; **B**, vagal trigone; **C**, vestibular area. The *arrows* indicate an internal lateral medullary vein (see p. 36)
The *lines* represent the planes of Figs. 118, 119 and 122

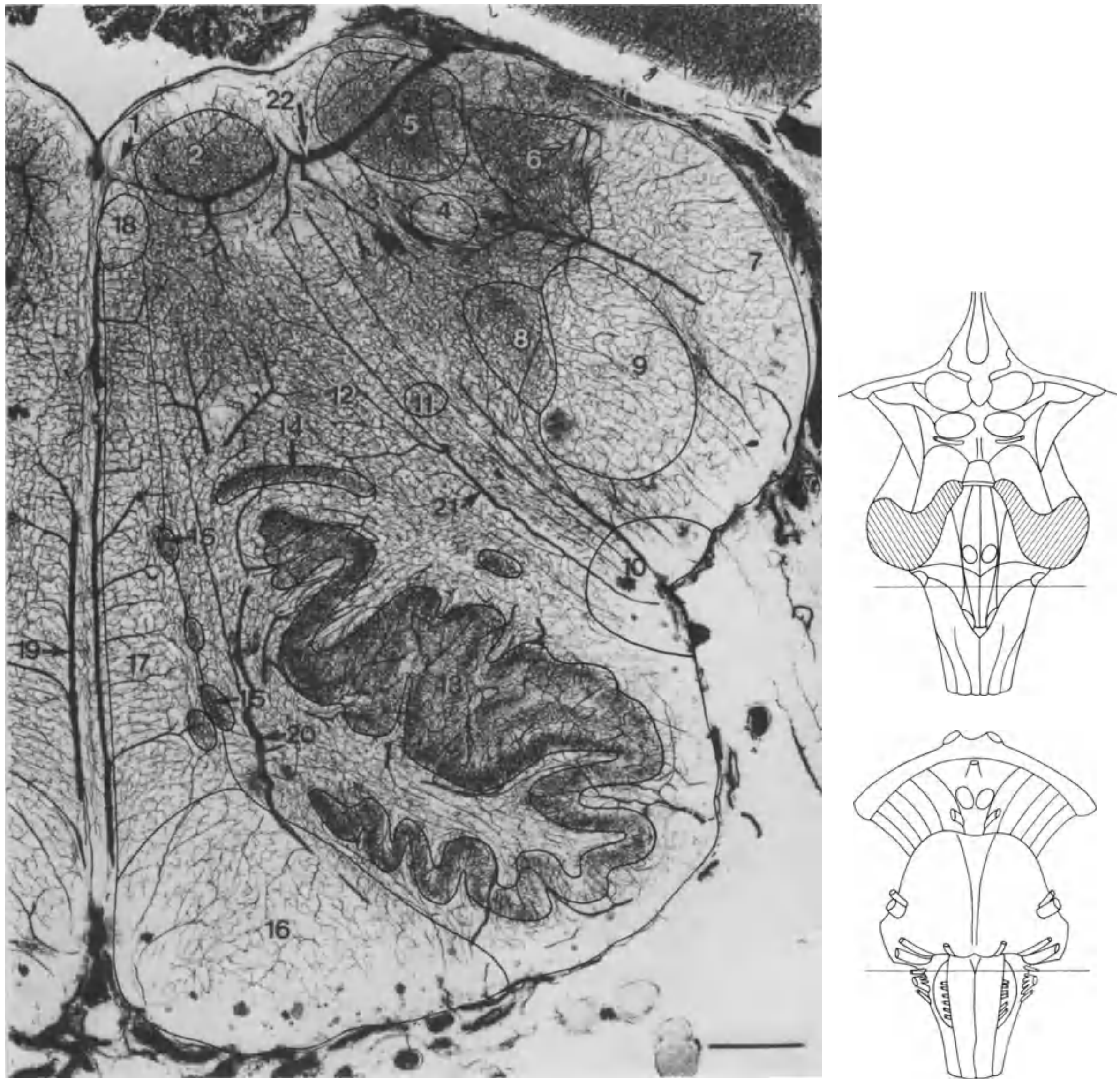


Fig. 103. Transverse Section of the Medulla Oblongata (level of the cranial third of inferior olive). **Bar, 1.25 mm**

1, Paramedian nucleus; **2**, nucleus praepositus; **3**, nucleus of the solitary tract; **4**, solitary tract; **5**, medial vestibular nucleus; **6**, inferior vestibular nucleus; **7**, inferior cerebellar peduncle; **8**, spinal trigeminal nucleus (subnucleus interpolaris); **9**, spinal trigeminal tract; **10**, spinothalamic tract; **11**, nucleus ambiguus; **12**, nucleus reticularis medullae oblongatae centralis; **13**, inferior olivary nucleus; **14**, dorsal accessory olivary nucleus; **15**, medial accessory olivary nucleus; **16**, corticospinal tract; **17**, medial lemniscus; **18**, medial longitudinal fasciculus; **19**, internal anteromedial medullary vessels; **20**, internal anterolateral medullary vessels; **21**, internal lateral medullary vessels; **22**, principal posterior (subependymal) medullary vein draining in this case the most of the vascular network of the ventricular floor nuclei

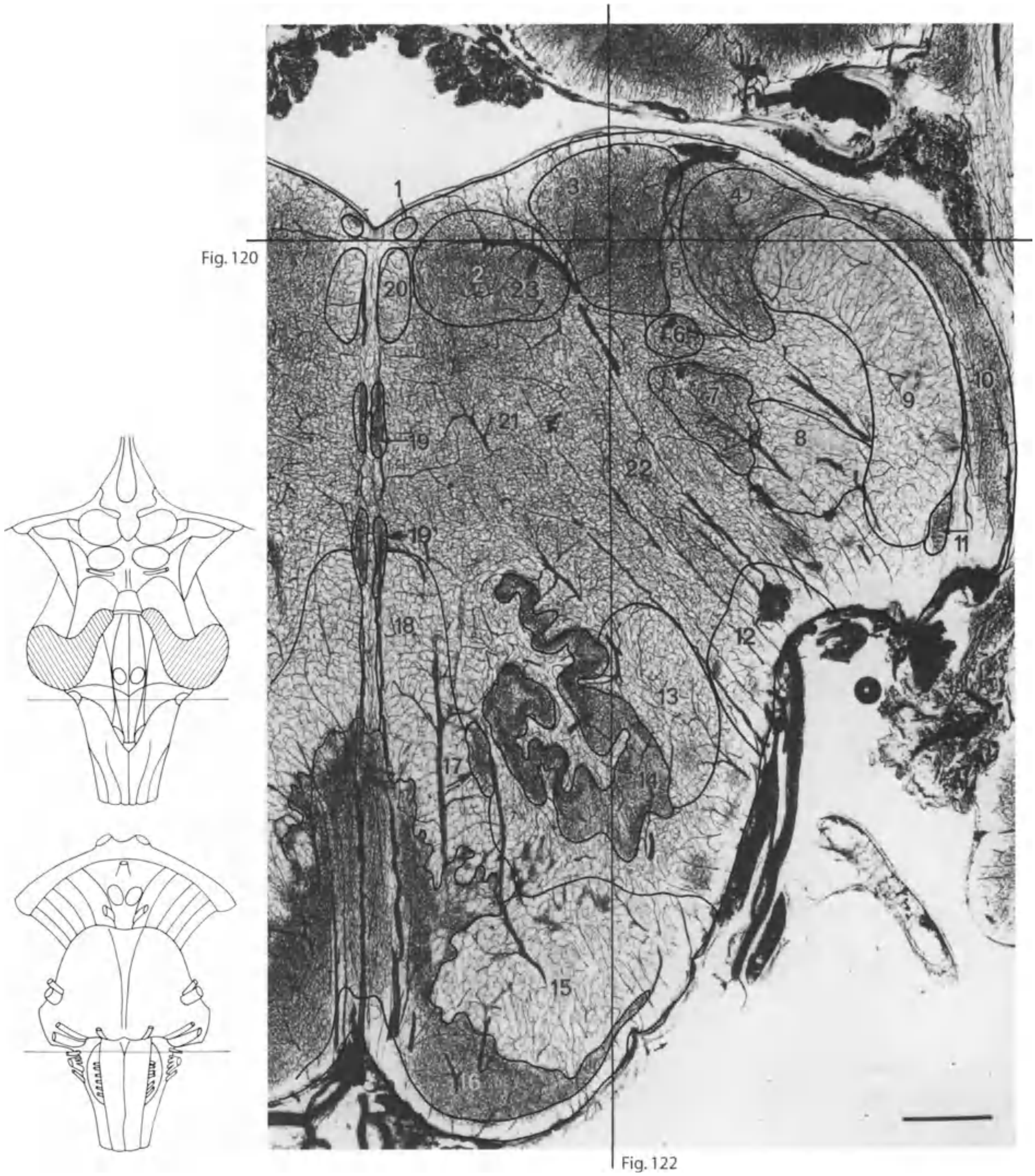


Fig. 104. Transverse Section of the Medulla Oblongata (level of the cranial third of the inferior olive. **Bar, 1.25 mm**

1, Paramedian nucleus; **2**, nucleus praepositus; **3**, medial vestibular nucleus; **4**, inferior vestibular nucleus; **5**, descending vestibular root; **6**, nucleus ovalis (see p. 146); **7**, spinal trigeminal nucleus (subnucleus oralis); **8**, spinal trigeminal tract; **9**, inferior cerebellar peduncle; **10**, dorsal cochlear nucleus; **11**, pontobulbar nucleus; **12**, spinothalamic tract; **13**, central tegmental tract; **14**, inferior olivary nucleus; **15**, corticospinal tract; **16**, arcuate nucleus; **17**, medial accessory olivary nucleus; **18**, medial lemniscus; **19**, nucleus raphes obscurus; **19'**, nucleus raphes pallidus; **20**, medial longitudinal fasciculus; **21**, nucleus gigantocellularis; **22**, nucleus reticularis parvocellularis (superior extension of nucleus reticularis medullae oblongatae centralis). **23**, In this case, an internal principal vein belonging to the lateral group of internal medullary vessels, drains most of the vascular network of the ventricular floor nuclei (see p. 36)
The *lines* represent the planes of Figs. 120 and 122

Fig. 105. Transverse Section of the Medulla Oblongata (level of the cranial pole of the inferior olive). **Bar, 1.4 mm**

1, Paramedian nucleus; **2**, nucleus praepositus; **3**, nucleus interpositus; **4**, medial vestibular nucleus; **5**, inferior vestibular nucleus; **6**, descending vestibular root; **7**, nucleus ovalis (see p. 146); **8**, spinal trigeminal nucleus (subnucleus oralis); **9**, spinal trigeminal tract; **10**, inferior cerebellar peduncle; **11**, ventral cochlear nucleus; **12**, pontobulbar nucleus; **13**, spinothalamic tract; **14**, central tegmental tract; **15**, inferior olivary nucleus; **16**, corticospinal tract; **17**, arcuate nucleus; **18**, medial lemniscus; **19**, nucleus raphes magnus; **20**, medial longitudinal fasciculus; **21**, nucleus gigantocellularis; **22**, nucleus reticularis parvocellularis

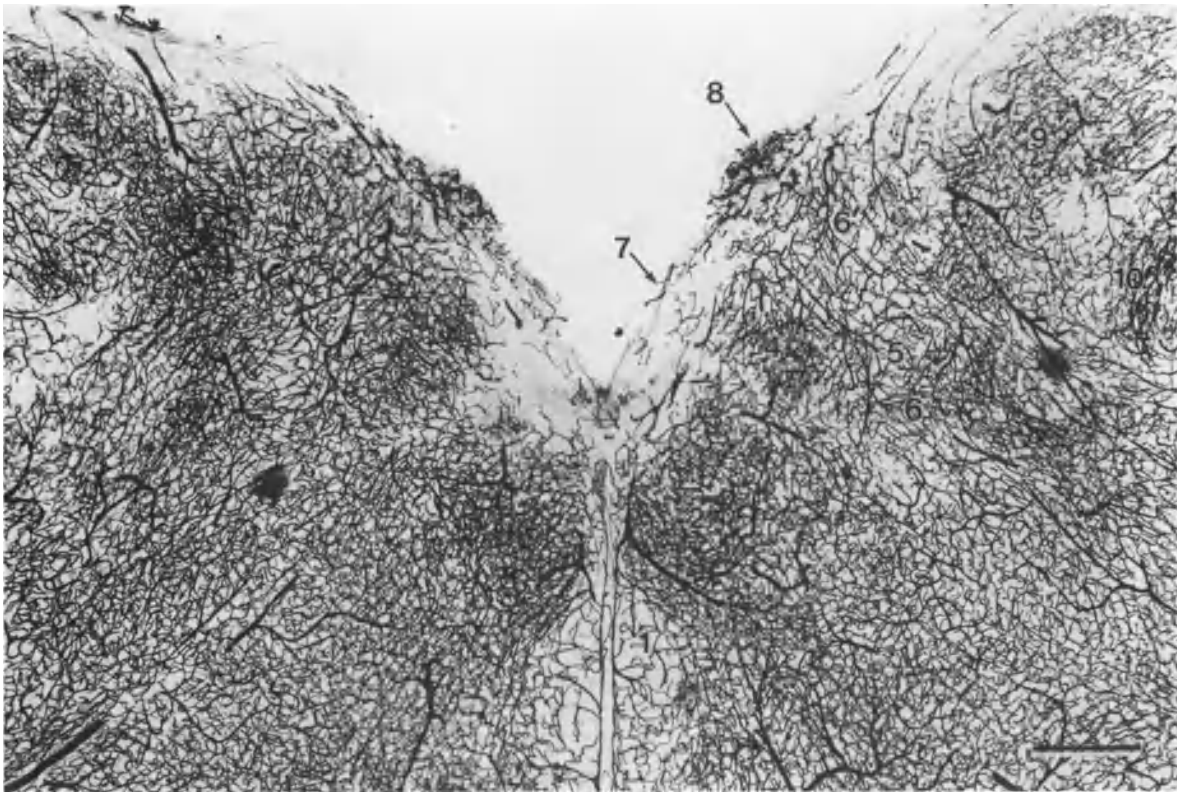
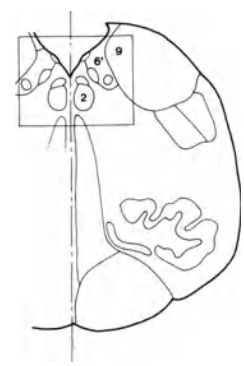


Fig. 106. Transverse Section of the Medulla Oblongata (floor of the fourth ventricle). Bar, 740 μm



1, Medial longitudinal fasciculus; **2**, hypoglossal nucleus; **3**, nucleus intercalatus; **4**, dorsal motor vagal nucleus; **5**, solitary tract; **6**, nucleus of the solitary tract; **6'**, nucleus gelatinosus (dorsal visceral grey see p. 146) belonging to the nucleus of the solitary tract; **7**, funiculus separans; **8**, area postrema; **9**, gracile nucleus; **10**, cuneate nucleus

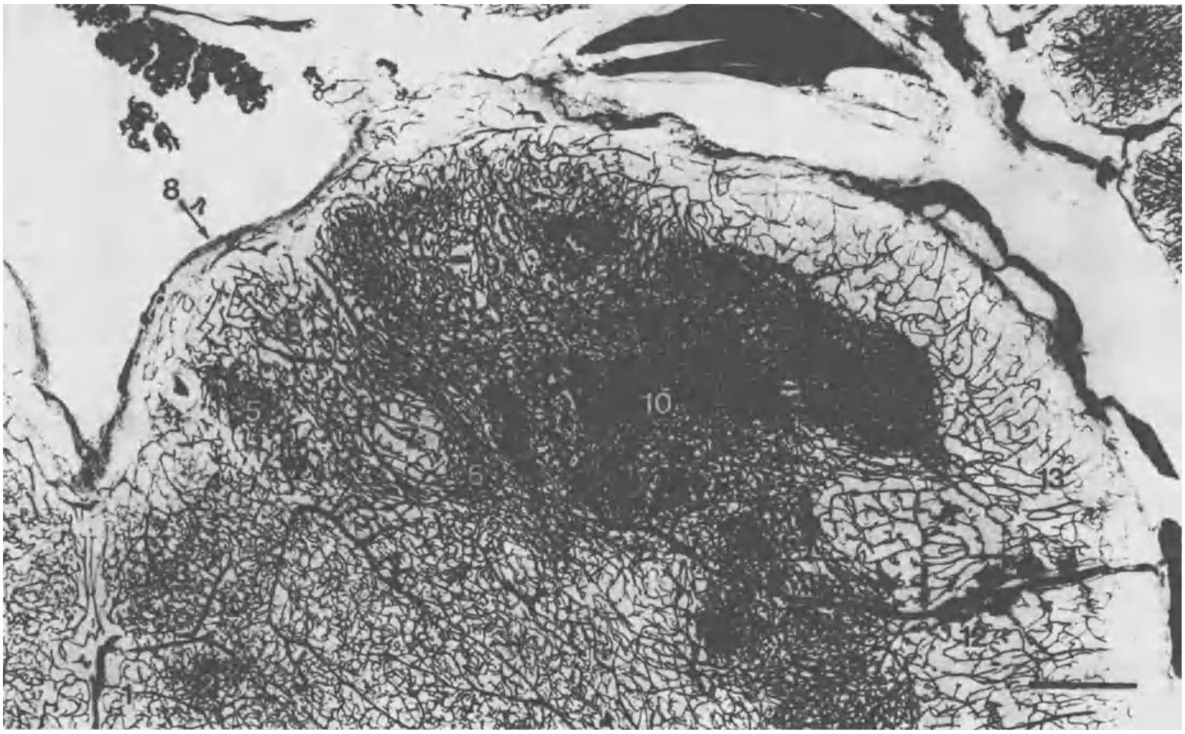
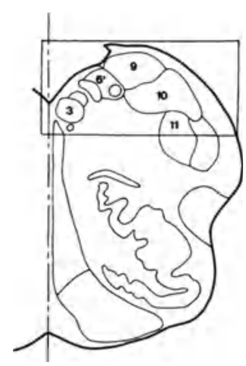
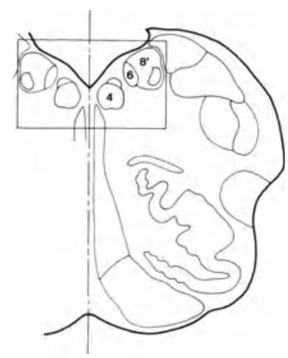


Fig. 107. Transverse Section of the Medulla Oblongata (floor of the fourth ventricle). Bar, 830 μm



1, Medial longitudinal fasciculus; **2**, sublingual nucleus (of Roller) (see Fig. 101); **3**, hypoglossal nucleus; **4**, nucleus intercalatus; **5**, dorsal motor vagal nucleus; **6**, nucleus of the solitary tract; **6'**, nucleus gelatinosus (see Fig. 101); **7**, solitary tract; **8**, vagal trigone (caudal prominent part); **9**, medial vestibular nucleus; **10**, accessory cuneate nucleus; **11**, spinal trigeminal nucleus (subnucleus interpolaris); **12**, spinal trigeminal tract; **13**, inferior cerebellar peduncle
An *arrow* indicates an artery supplying the trigeminal nucleus and belonging to lateral group of internal medullary vessels (see p. 36)

Fig. 108. Transverse Section of the Medulla Oblongata (floor of the fourth ventricle). **Bar, 740 μm**



1, Medial lemniscus; **2**, medial longitudinal fasciculus; **3**, sublingual nucleus (of Roller); **4**, hypoglossal nucleus; **5**, nucleus intercalatus; **6**, dorsal motor vagal nucleus; **7**, solitary tract; **8**, nucleus of the solitary tract; **8′**, nucleus gelatinosus (belonging to the nucleus of the solitary tract); **9**, medial vestibular nucleus
An *arrow* indicates a vein belonging to the internal lateral group of medullary vessels and draining the blood of dorsal motor vagal and hypoglossal nuclei

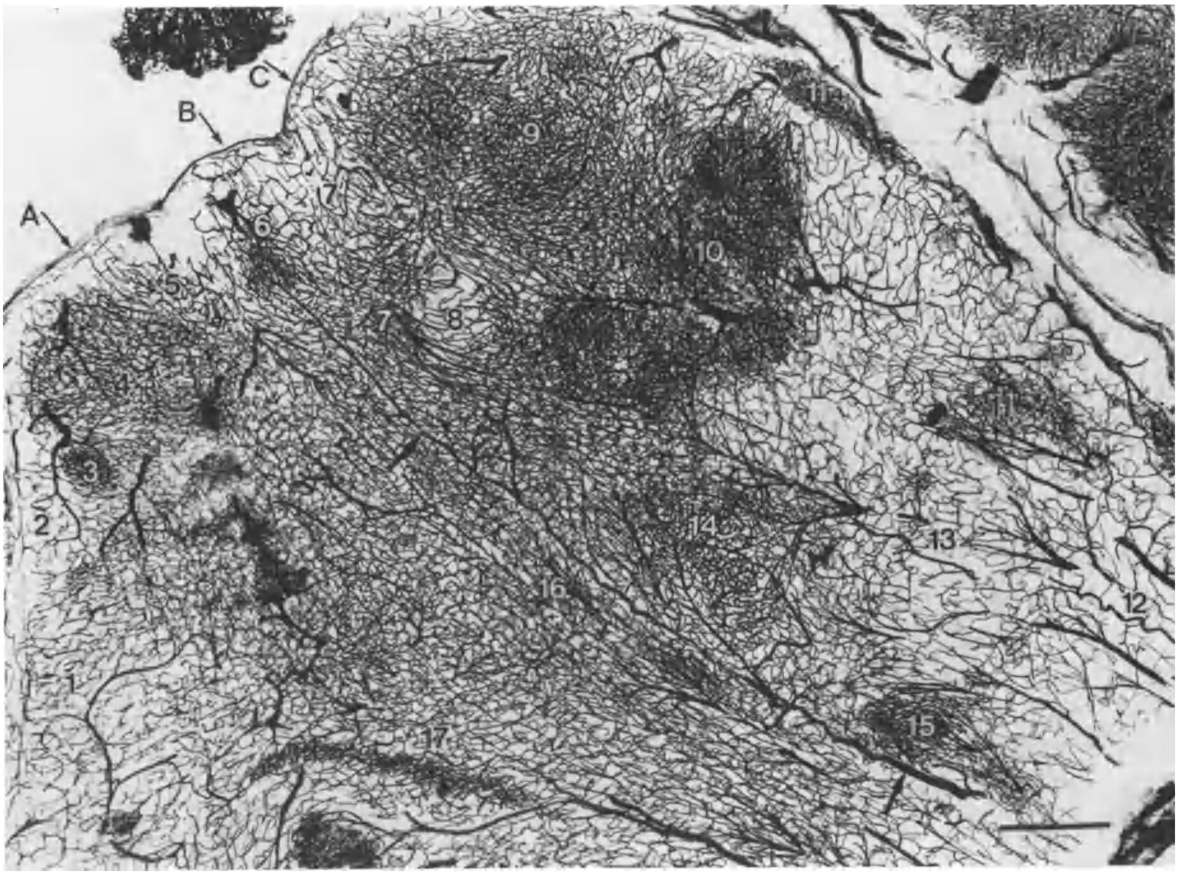
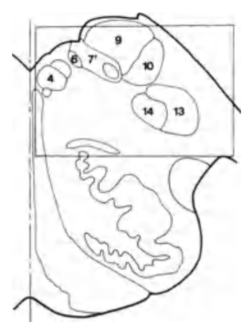


Fig. 109. Transverse Section of the Medulla Oblongata (floor of the fourth ventricle). **Bar, 830 µm**



1, Medial lemniscus; **2**, medial longitudinal fasciculus; **3**, sublingual nucleus (of Roller); **4**, hypoglossal nucleus; **5**, nucleus intercalatus; **6**, dorsal motor vagal nucleus; **7**, nucleus of the solitary tract; **7'**, nucleus gelatinosus (belonging to the nucleus of solitary tract); **8**, solitary tract; **9**, medial vestibular nucleus; **10**, accessory cuneate nucleus; **11**, pontobulbar nucleus; **12**, vagus nerve; **13**, spinal trigeminal tract; **14**, spinal trigeminal nucleus (subnucleus interpolaris); **15**, nucleus reticularis lateralis; **16**, nucleus ambiguus; **17**, dorsal accessory olivary nucleus; **A**, hypoglossal trigone; **B**, vagal trigone; **C**, vestibular area
The *arrows* indicate an internal lateral medullary artery supplying the dorsal motor vagal nucleus (see p. 36)

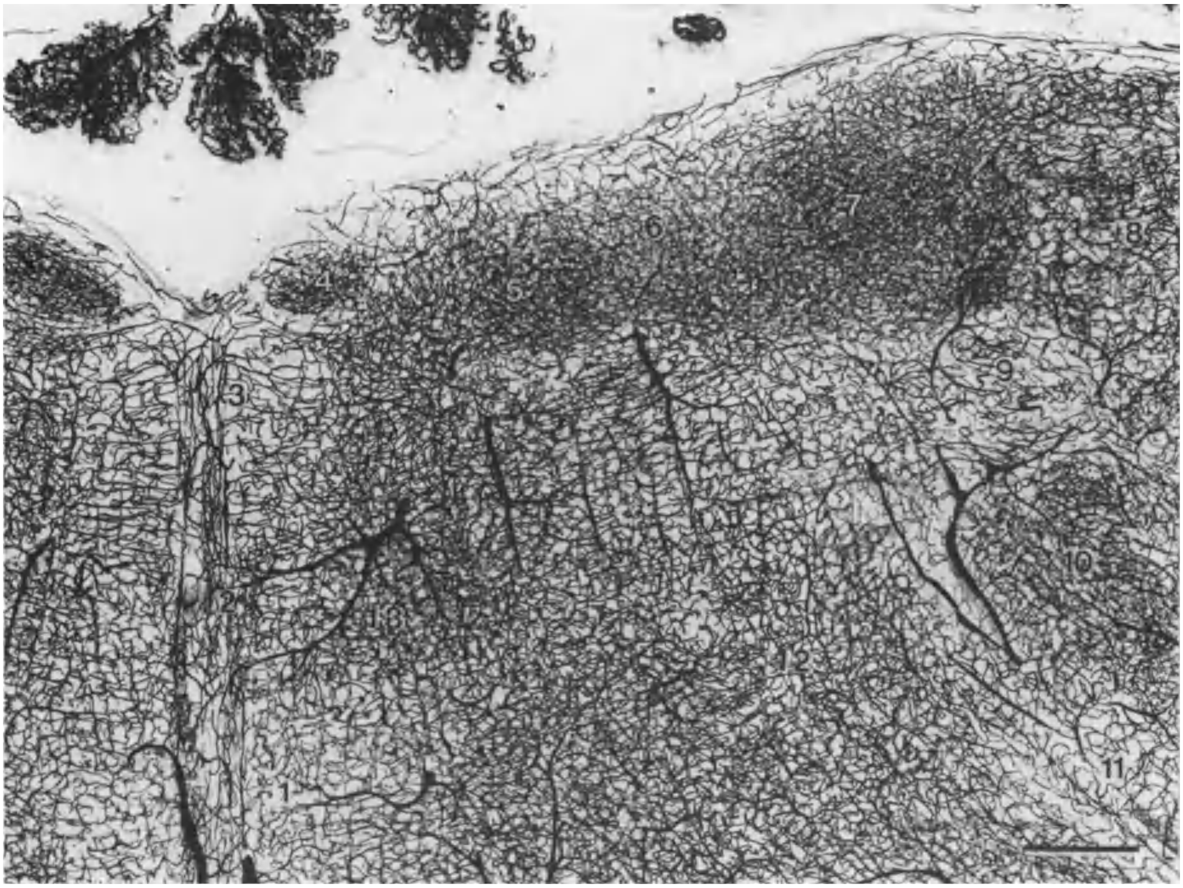
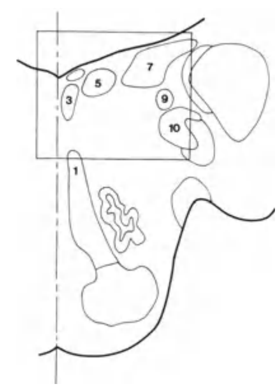
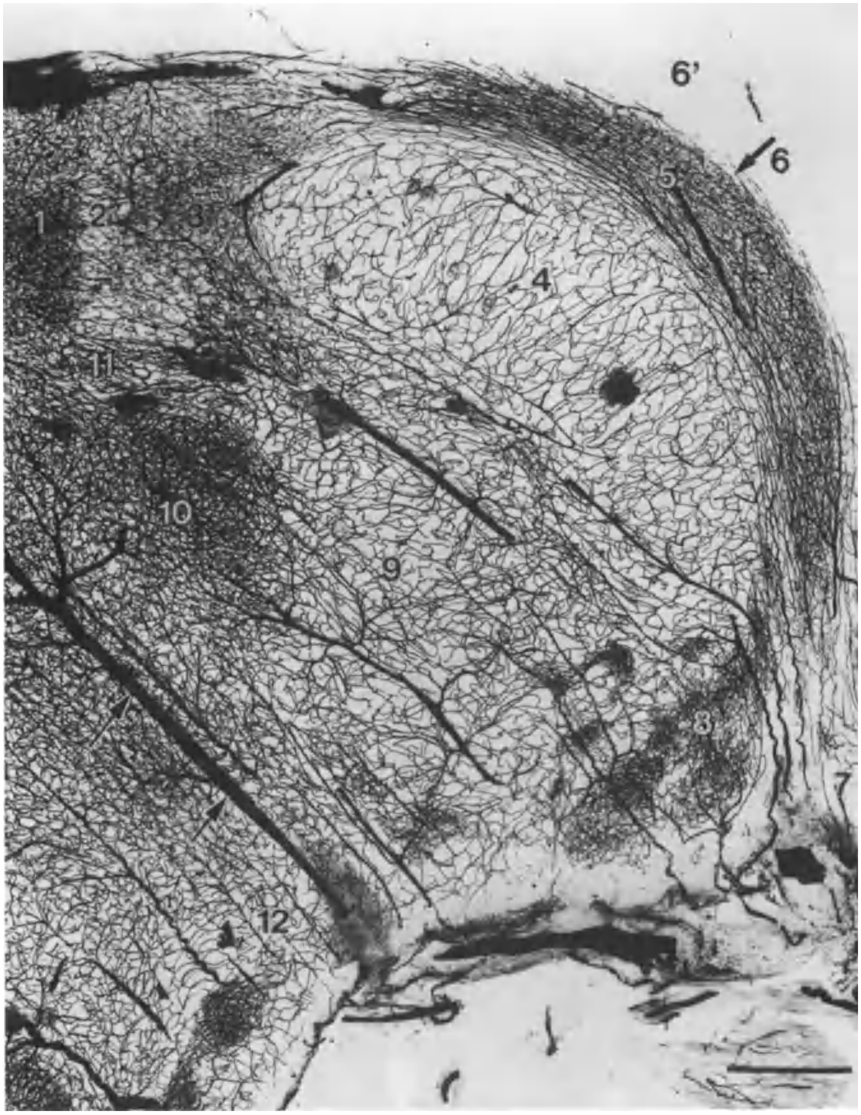


Fig. 110. Transverse Section of the Medulla Oblongata (floor of the fourth ventricle, cranial to the level shown in Figs. 108 and 109). **Bar, 710 μm**



1, Medial lemniscus; 2, nucleus raphes obscurus; 3, medial longitudinal fasciculus; 4, paramedian nucleus; 5, nucleus praepositus; 6, nucleus interpositus; 7, medial vestibular nucleus; 8, inferior vestibular nucleus; 9, solitary tract; 10, spinal trigeminal nucleus (subnucleus oralis); 11, spinal trigeminal tract; 12, nucleus reticularis parvocellularis; 13, nucleus gigantocellularis



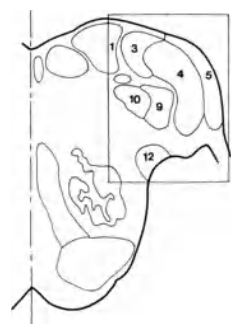


Fig. 111. Transverse Section of the Medulla Oblongata (level of dorsal cochlear nucleus). **Bar, 800 µm**

1, Medial vestibular nucleus; **2**, descending vestibular root; **3**, inferior vestibular nucleus; **4**, inferior cerebellar peduncle; **5**, dorsal cochlear nucleus; **6**, acoustic tubercle; **6'**, fourth ventricle; **7**, vestibulocochlear nerve; **8**, pontobulbar nucleus; **9**, spinal trigeminal tract; **10**, spinal trigeminal nucleus (subnucleus oralis); **11**, nucleus ovalis (see p. 146); **12**, spinothalamic tract
The *arrows* indicate a principal internal lateral vein (see p. 36)

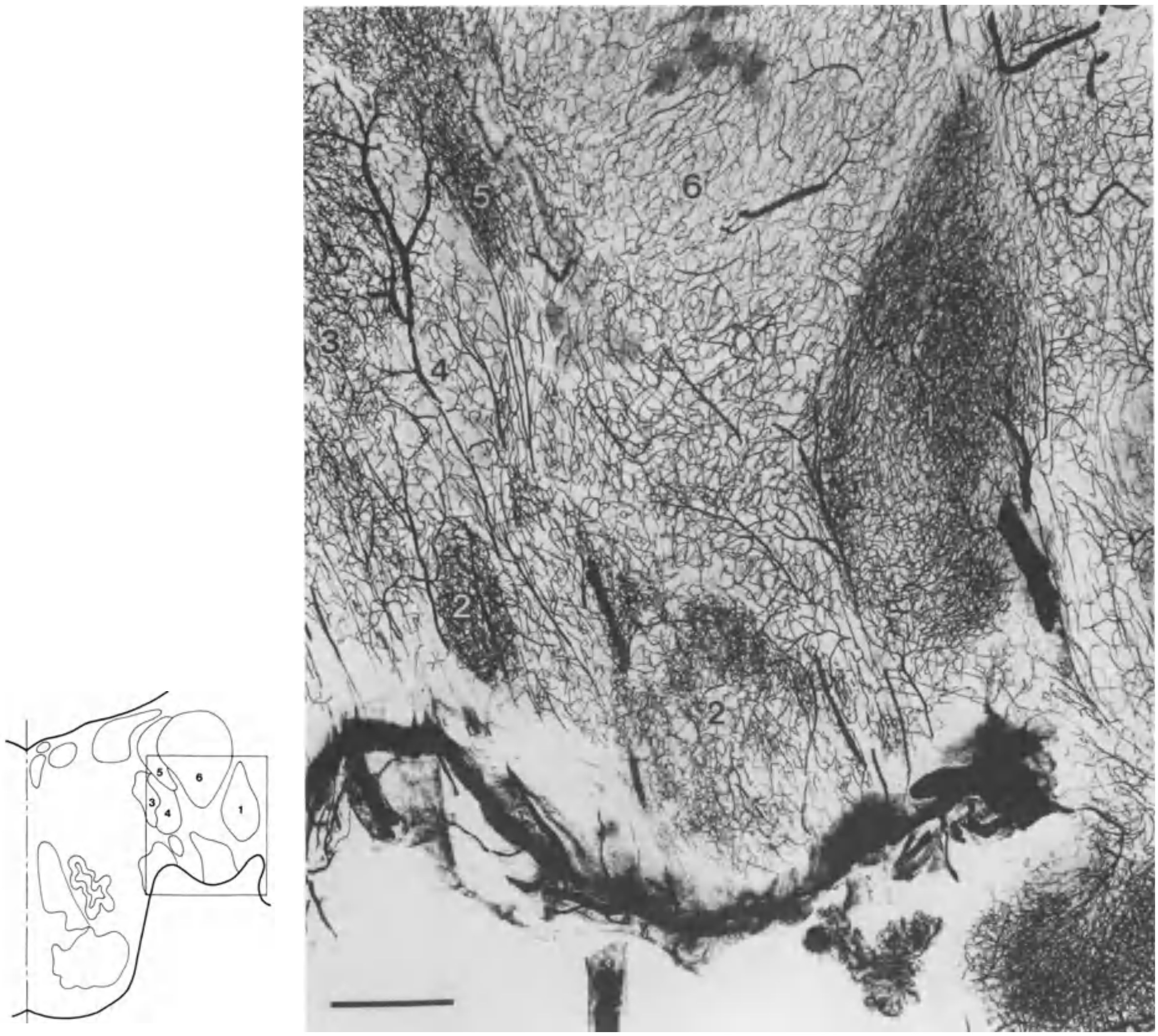


Fig. 112. Transverse Section of the Medulla Oblongata (level of ventral cochlear nucleus). Bar, 1 mm

1, Ventral cochlear nucleus; **2**, pontobulbar nucleus; **3**, spinal trigeminal nucleus; **4**, spinal trigeminal tract; **5**, inferior vestibular nucleus; **6**, inferior cerebellar peduncle

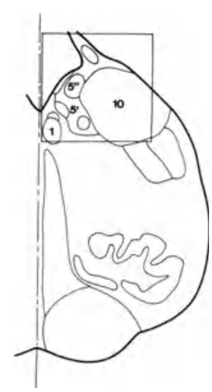


Fig. 113. Transverse Section of the Medulla Oblongata (part of the floor of the fourth ventricle). **Bar, 650 µm**

1, Hypoglossal nucleus; **2**, nucleus intercalatus; **3**, dorsal motor vagal nucleus; **4**, solitary tract; **5**, nucleus of the solitary tract; **5'**, nucleus pigmentosus nervi vagi and 5" nucleus gelatinosus; these two nuclei belong to the nucleus of the solitary tract; **6**, area postrema (lateral part); **7**, fourth ventricle; **8**, ligula (taenia of the fourth ventricle); **9**, pontocerebellar nucleus; **10**, accessory cuneate nucleus

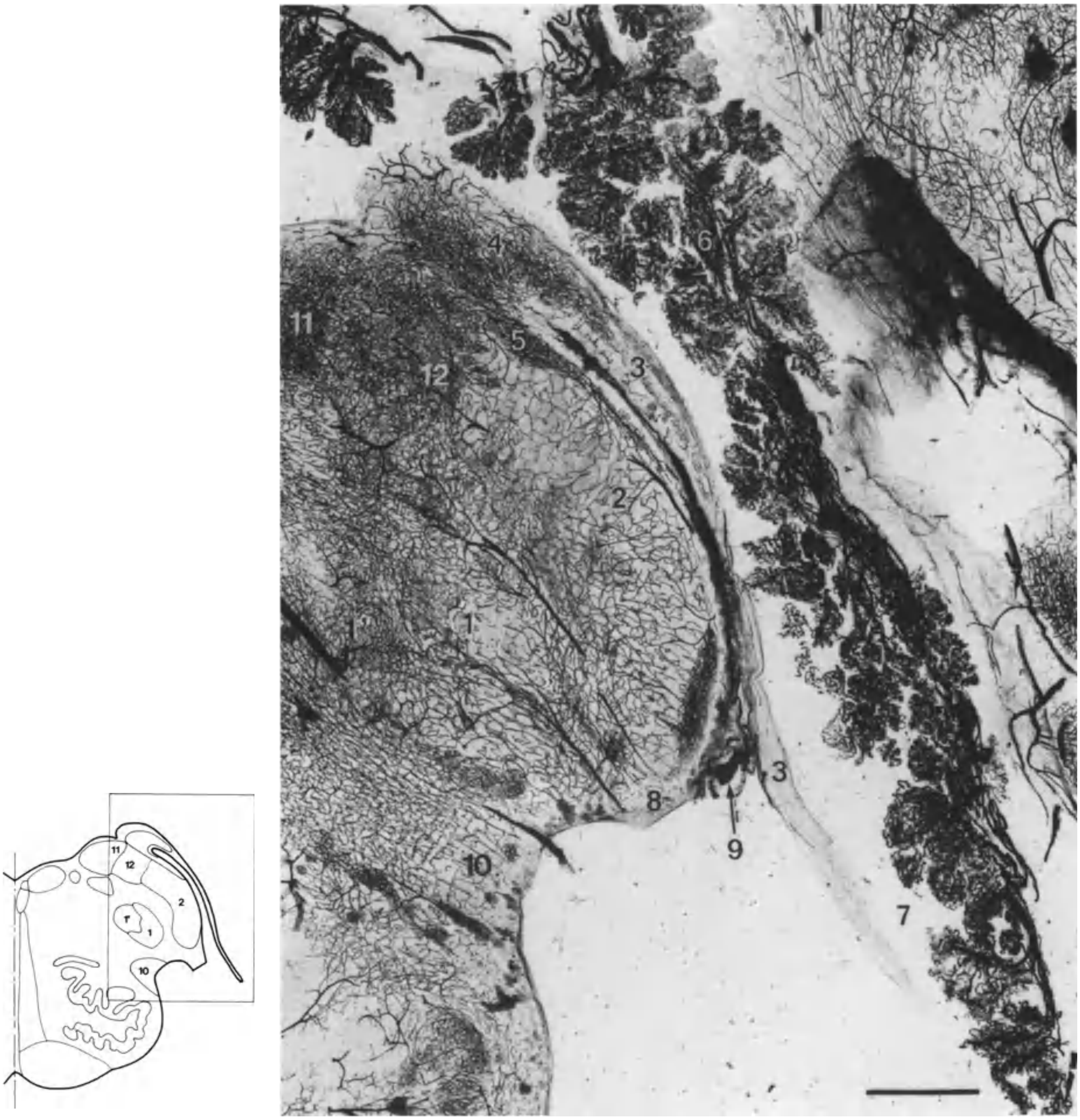


Fig. 114. Transverse Section of the Medulla Oblongata
Bar, 1.2 mm

1, Spinal trigeminal tract; **1'**, spinal trigeminal nucleus; **2**, inferior cerebellar peduncle; **3**, ligula (taenia of the fourth ventricle); **4**, vascular plexus of the taenia (pontocerebellar nucleus extending along the inferior cerebellar peduncle); **5**, nucleus marginalis corporis restiformis; **6**, choroid plexus of the lateral recess of the fourth ventricle; **7**, lateral aperture (LUSCHKA) of the fourth ventricle; **8**, vagus nerve; **9**, lateral medullary vein (see p. 34); **10**, spinothalamic tract; **11**, medial vestibular nucleus; **12**, inferior vestibular nucleus

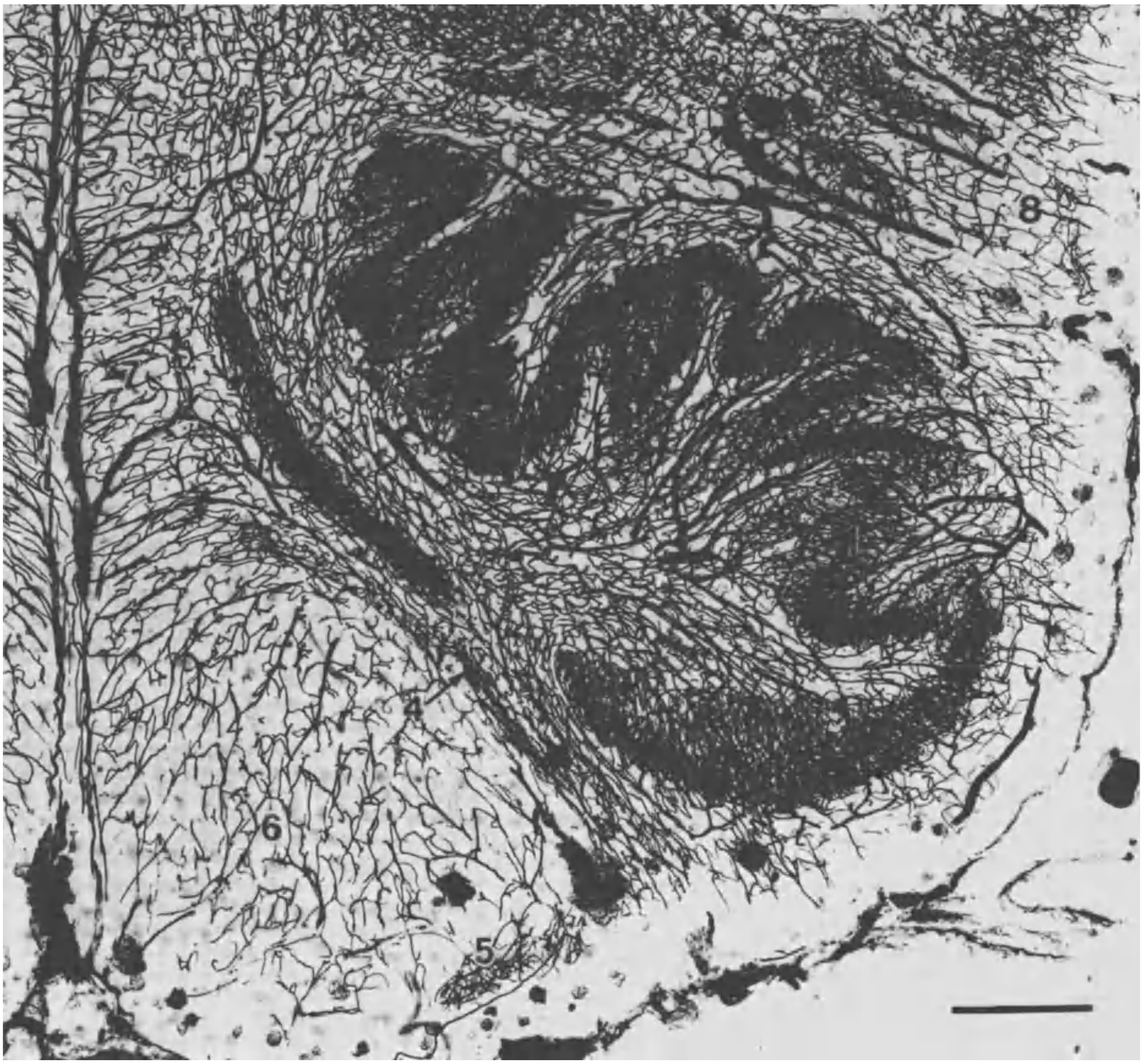
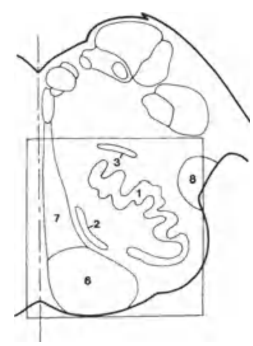


Fig. 115. Transverse Section of the Medulla Oblongata (detail showing the inferior olive). **Bar, 900 μm**



1, Inferior olivary nucleus; **2**, medial accessory olivary nucleus; **3**, dorsal accessory olivary nucleus; **4**, arcuate nucleus (nucleus conterminalis); **5**, arcuate nucleus; **6**, corticospinal tract; **7**, medial lemniscus; **8**, spinothalamic tract

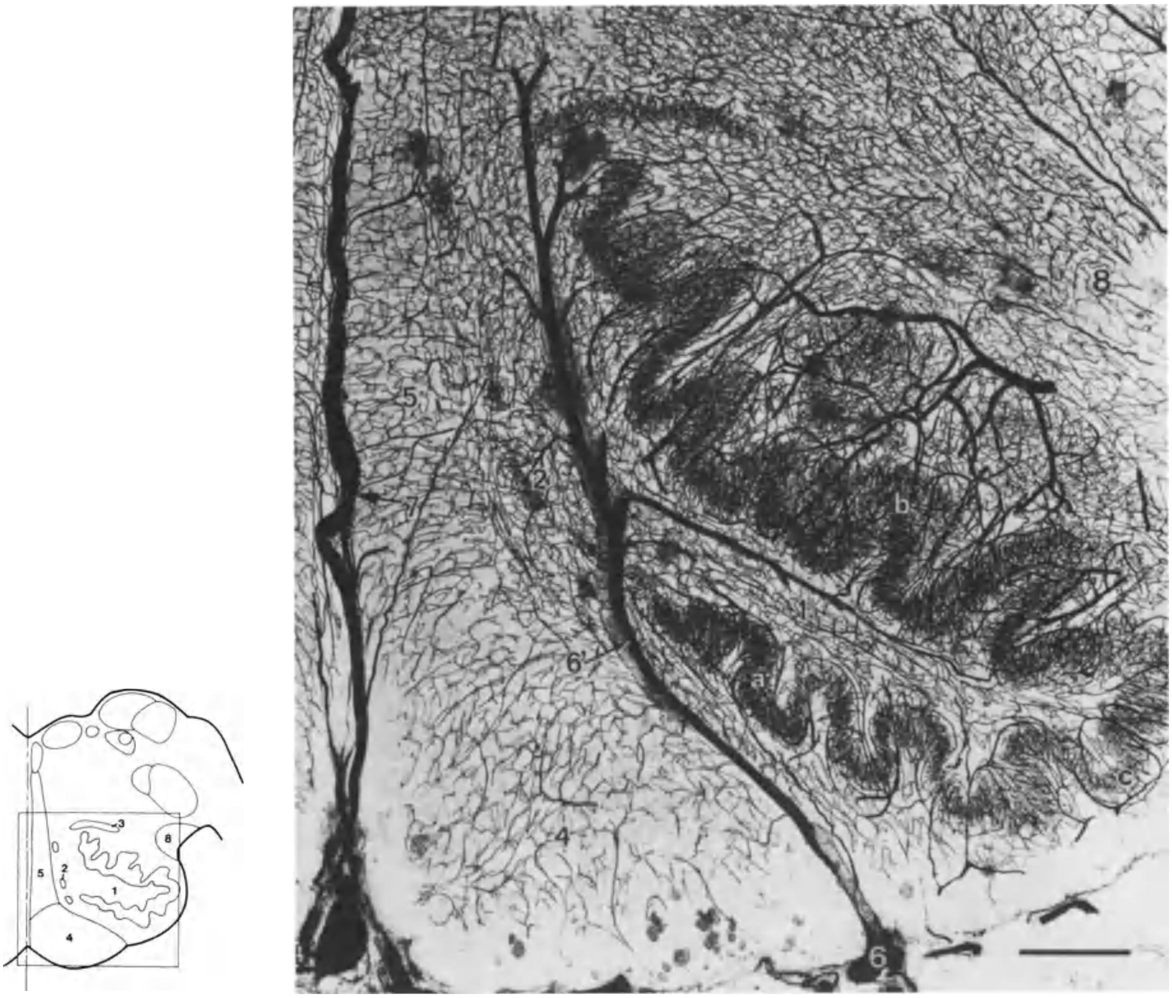


Fig. 116. Transverse Section of the Medulla Oblongata (detail showing the inferior olive). **Bar, 950 µm**

1, Inferior olivary nucleus; **a**, medial part; **b**, lateral part; **c**, superficial part; **2**, medial accessory olivary nucleus; **3**, dorsal accessory olivary nucleus; **4**, corticospinal tract; **5**, medial lemniscus; **6**, lateral anterior (preolivary) medullary vein (see p. 32); **6'**, vein belonging to the internal anterolateral medullary group; **7**, artery belonging to the internal anteromedial medullary group (see p. 35); **8**, spinothalamic tract

Fig. 117. Transverse Section of the Medulla Oblongata Showing the Right Inferior Olive. **Bar, 950 μm**

1, Inferior olivary nucleus; **2**, medial accessory olivary nucleus; **3**, dorsal accessory olivary nucleus; **4**, central olivary vein (see p. 38); **5**, corticospinal tract; **6**, spinothalamic tract; **7**, nucleus reticularis lateralis

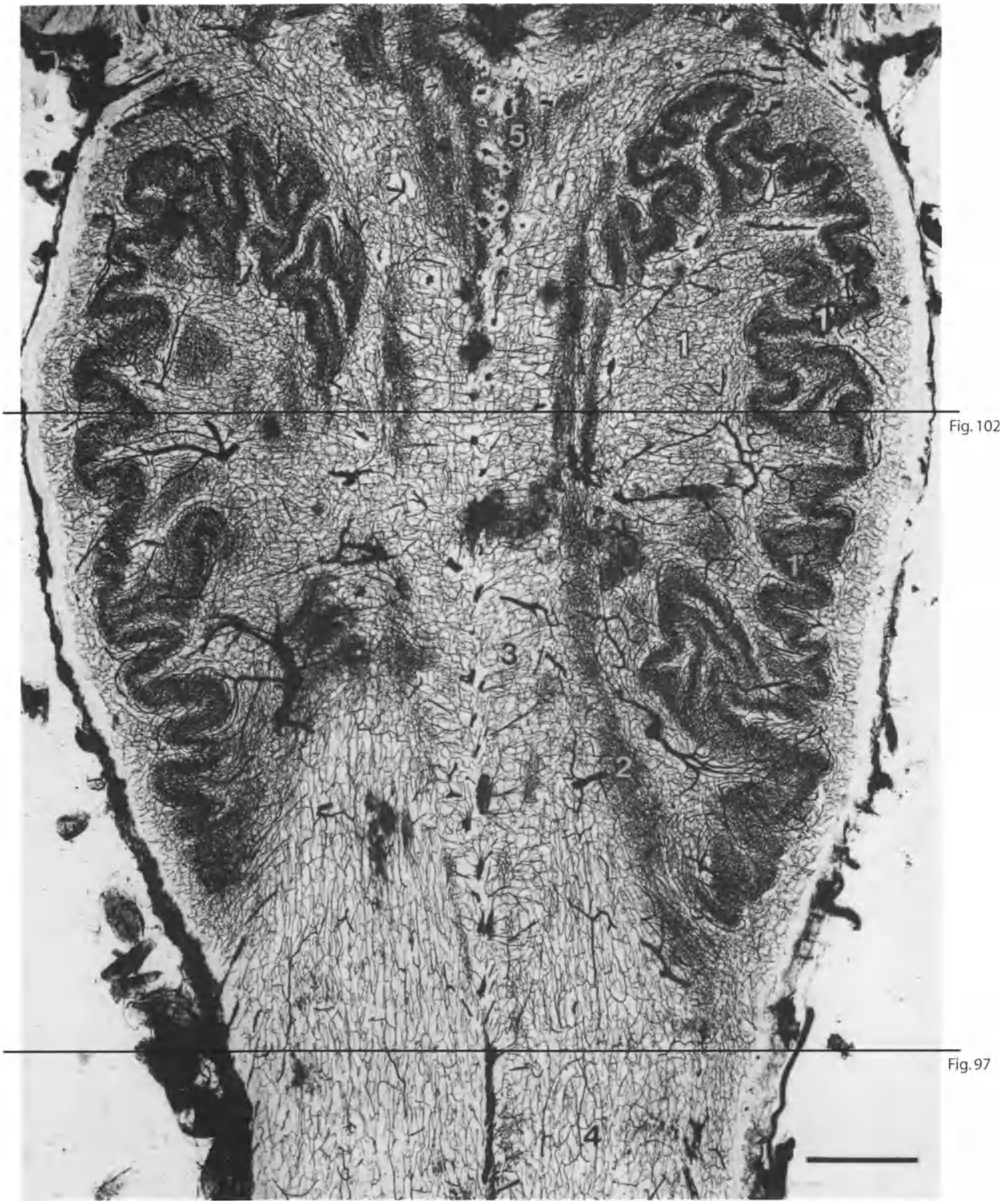


Fig. 118. Coronal Section of the Medulla Oblongata (in the plane indicated in Figs. 97 and 102). **Bar, 2 mm**

1, Hilum of the inferior olivary nucleus; **1'**, inferior olivary nucleus; **2**, medial accessory olivary nucleus; **3**, medial lemniscus; **4**, corticospinal tract; **5**, arcuate nucleus

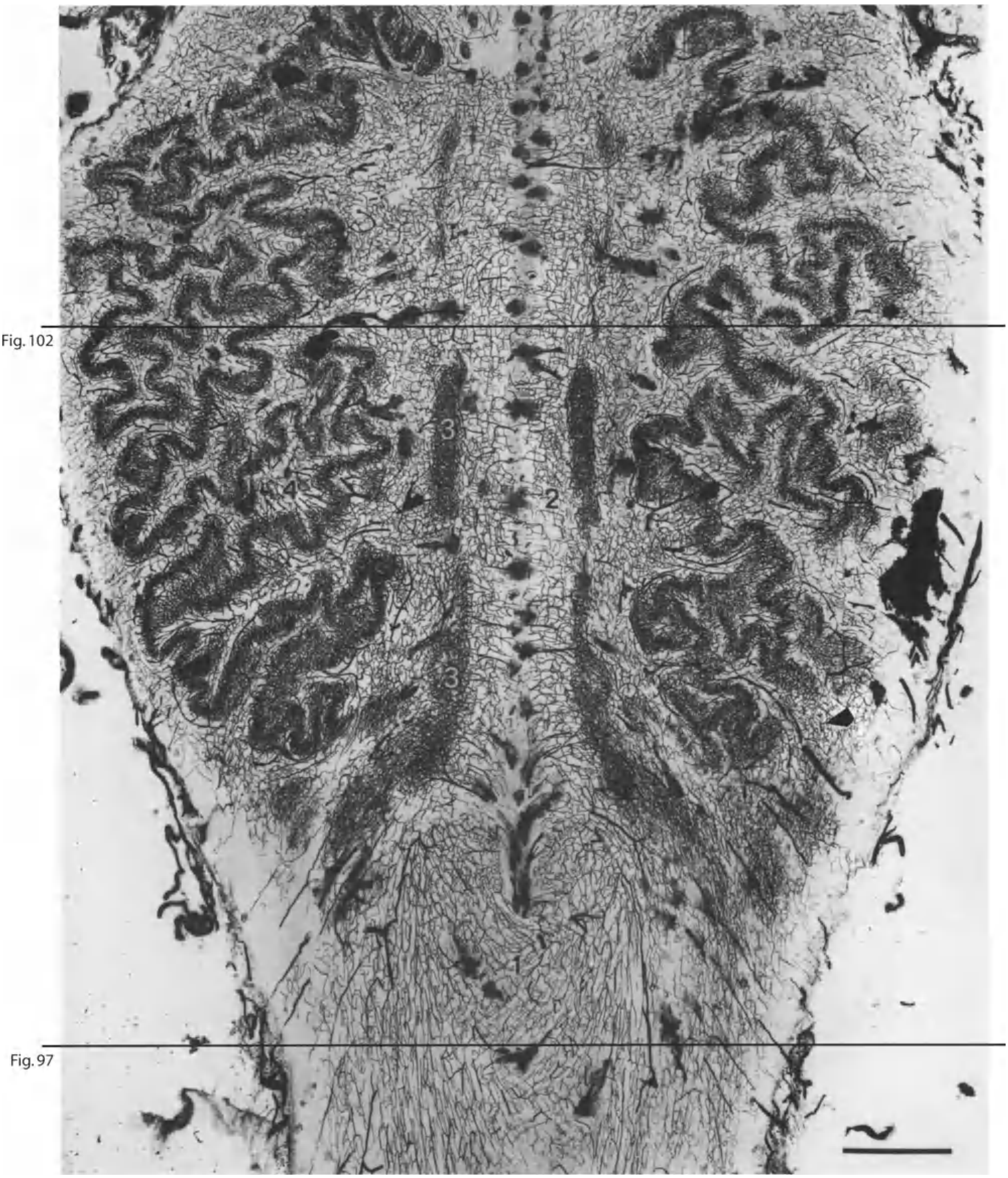


Fig. 119. Coronal Section of the Medulla Oblongata (in the plane indicated in Figs. 97 and 102). **Bar, 2 mm**

1, Decussation of the pyramids (corticospinal tract); **2**, medial lemniscus; **3**, medial accessory olivary nucleus; **4**, inferior olivary nucleus

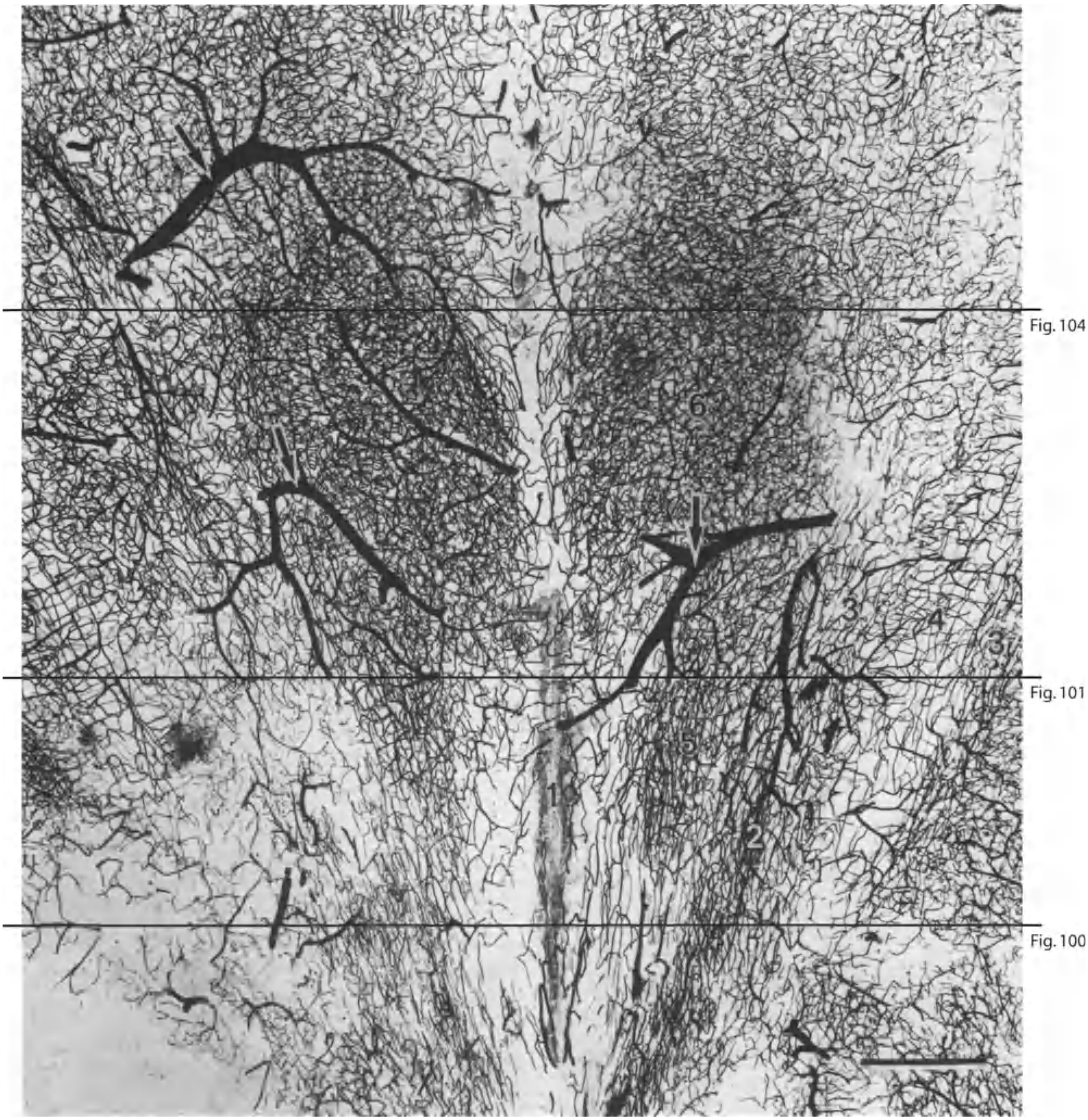


Fig. 120. Coronal Section of the Medulla Oblongata (in the plane indicated in Figs. 100, 101, 104). **Bar, 930 µm**

1, Median sulcus of the floor of the fourth ventricle; **2**, dorsal motor vagal nucleus; **3**, nucleus of the solitary tract; **4**, solitary tract; **5**, hypoglossal nucleus; **6**, nucleus praepositus
Arrows indicate veins belonging to the internal lateral medullary group

Fig. 121. Sagittal (or Paramedian) Section of the Medulla Oblongata (in the plane indicated in Figs. 97, 99, 100 and 101)
Bar, 2 mm

1, Decussation of the pyramids; **2**, corticospinal tract; **3**, medial lemniscus; **4**, arcuate nucleus; **5**, pontine nuclei; **6**, hypoglossal nucleus; **7**, sublingual nucleus (of Roller); **8**, dorsal motor vagal nucleus; **9**, area postrema; **10**, nucleus of the solitary tract; **11**, gracile nucleus
Arrows indicate blood vessels belonging to the internal anteromedial medullary group

Fig. 122. Sagittal (or Paramedian) Section of the Medulla Oblongata (in the plane indicated in Figs. 99, 102 and 104)
Bar, 2 mm

1, Corticospinal tract; **2**, medial accessory olivary nucleus; **3**, inferior olivary nucleus; **4**, dorsal accessory olivary nucleus; **5**, hilum of the inferior olive; **6**, gracile nucleus; **7**, dorsal motor vagal nucleus; **8**, medial vestibular nucleus; **9**, pontine nuclei

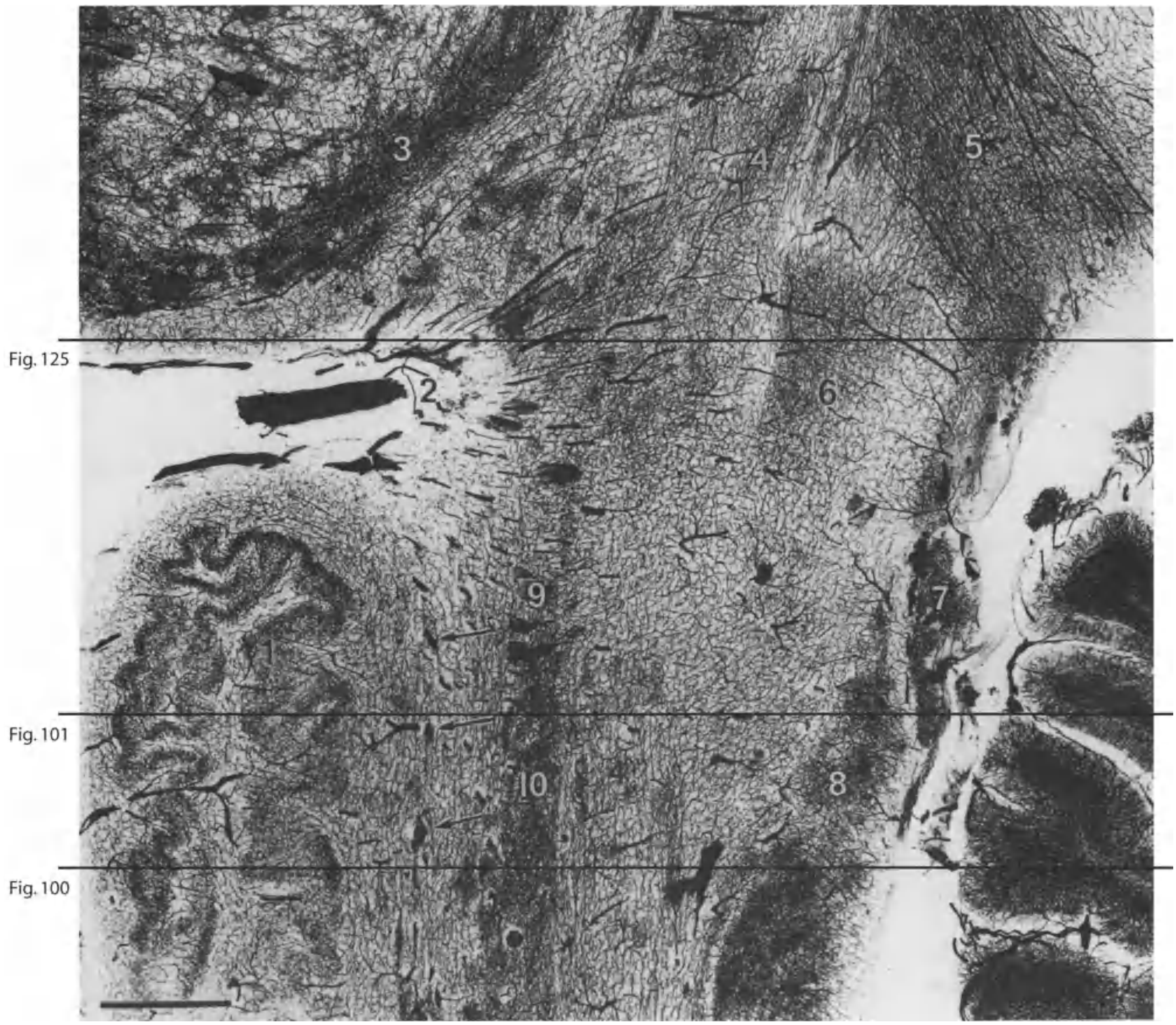
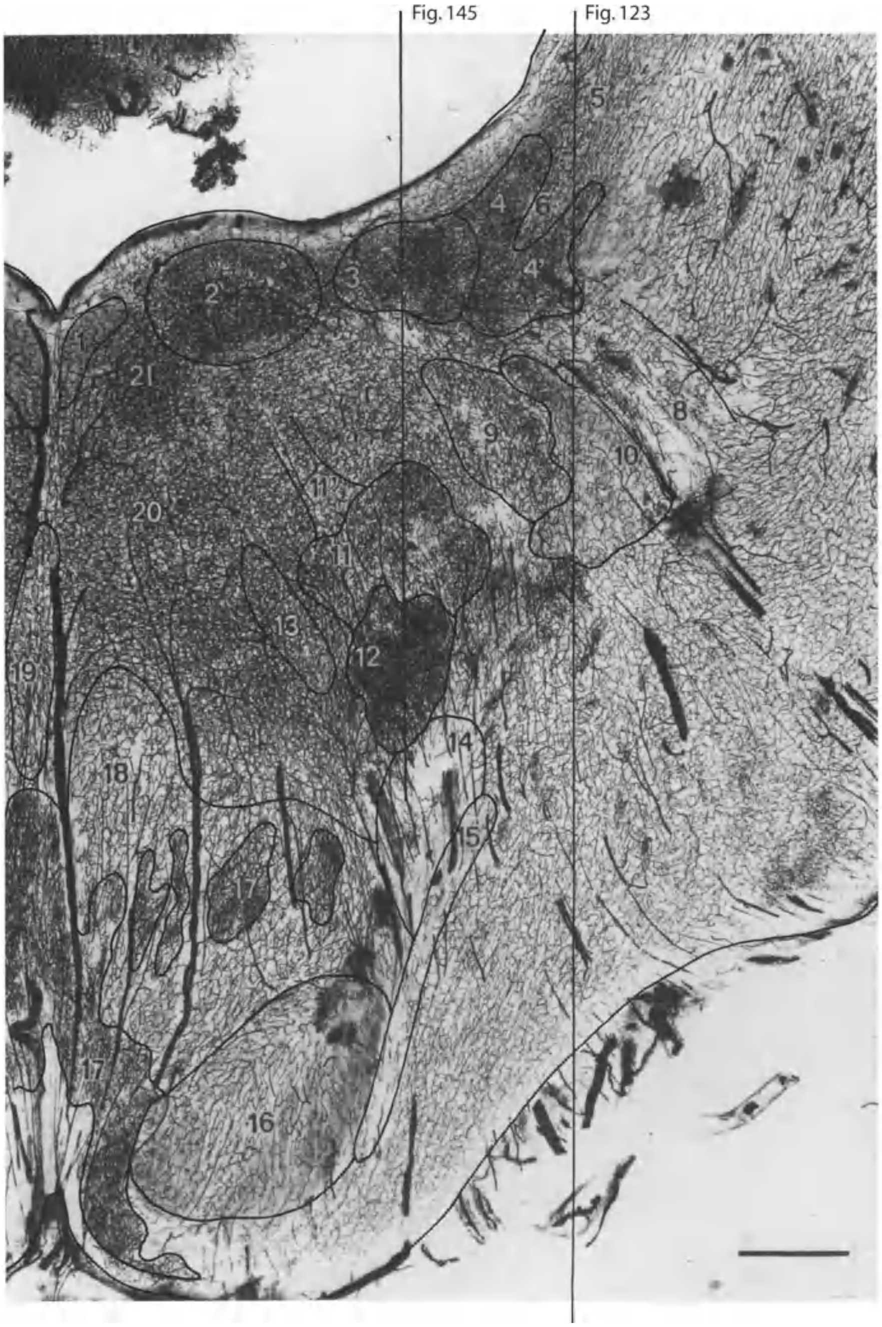


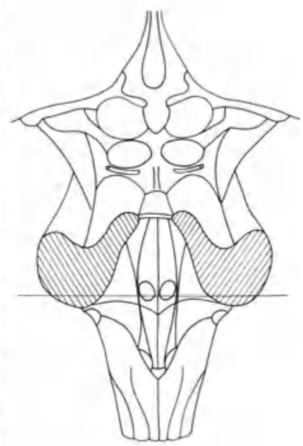
Fig. 123. Sagittal (Paramedian) Section of the Superior Part of the Medulla Oblongata and of the Inferior Part of the Pons (in the plane indicated in Figs. 100, 101 and 125). **Bar, 2.5 mm**

1, Inferior olivary nucleus; **2**, pontomedullary sulcus; **3**, pontine nuclei; **4**, spinal trigeminal tract; **5**, superior vestibular nucleus; **6**, lateral vestibular nucleus; **7**, medial vestibular nucleus; **8**, accessory cuneate nucleus; **9**, spinal trigeminal nucleus (subnucleus oralis); **10**, spinal trigeminal nucleus (subnucleus interpolaris)
The *arrows* indicate section of internal lateral medullary vessels

Fig. 124. Transverse Section of the Pons (level of pontomedullary sulcus). **Bar, 1.8 mm**

1, Medial longitudinal fasciculus; **2**, nucleus praepositus; **3**, nucleus interpositus; **4**, medial vestibular nucleus; **5**, superior vestibular nucleus; **6**, lateral vestibular nucleus; **7**, descending vestibular root; **8**, inferior vestibular nucleus; **9**, inferior cerebellar peduncle; **10**, spinal trigeminal nucleus (subnucleus oralis); **11**, spinal trigeminal tract; **12**, vestibulocochlear nerve; **13**, facial nucleus; **14**, superior olivary nucleus; **15**, central tegmental tract; **16**, spinothalamic tract; **16'**, pontomedullary sulcus; **17**, corticospinal tract; **18**, arcuate nucleus; **19**, medial lemniscus; **20**, nucleus raphes magnus; **21**, nucleus reticularis gigantocellularis





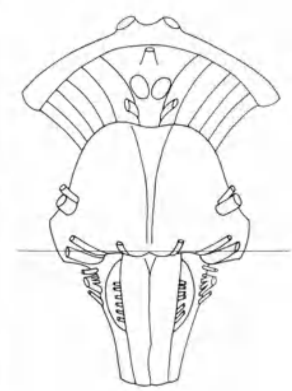


Fig. 125. Transverse Section of the Pons (level of pontomedullary sulcus). **Bar, 1.7 mm**

1, Medial longitudinal fasciculus; **2**, abducent nucleus; **3**, medial vestibular nucleus; **4**, lateral vestibular nucleus (medial part); **4'**, lateral vestibular nucleus (lateral part); **5**, superior vestibular nucleus; **6**, descending vestibular root; **7**, inferior cerebellar peduncle; **8**, vestibulocochlear nerve; **9**, spinal trigeminal nucleus (subnucleus oralis); **10**, spinal trigeminal tract; **11**, facial nucleus; **11'**, facial nerve; **12**, superior olivary nucleus; **13**, central tegmental tract; **14**, spinothalamic tract; **15**, pontomedullary sulcus; **16**, corticospinal tract; **17**, arcuate nucleus; **18**, medial lemniscus; **19**, nucleus raphes magnus; **20**, nucleus reticularis gigantocellularis; **21**, nucleus reticularis pontis caudalis
The *lines* represent the planes of Figs. 123 and 145

Fig. 126. Transverse Section of the Pons (inferior part)
Bar, 1.8 mm

1, Medial longitudinal fasciculus; **2**, genu of the facial nerve; **3**, abducent nucleus; **4**, facial nerve; **5**, lateral vestibular nucleus (medial part); **5'**, lateral vestibular nucleus (lateral part); **6**, superior vestibular nucleus; **7**, middle cerebellar peduncle; **8**, spinal trigeminal nucleus (subnucleus oralis); **9**, spinal trigeminal tract; **10**, superior olivary nucleus; **11**, lateral lemniscus ; **12**, pontine nuclei; **13**, pontocerebellar fibers; **14**, corticospinal tract; **15**, medial lemniscus; **16**, central tegmental tract; **17**, nucleus reticularis gigantocellularis; **18**, abducent nerve; **19**, nucleus reticularis pontis caudalis
The *lines* represent the planes of Figs. 137, 144 and 145

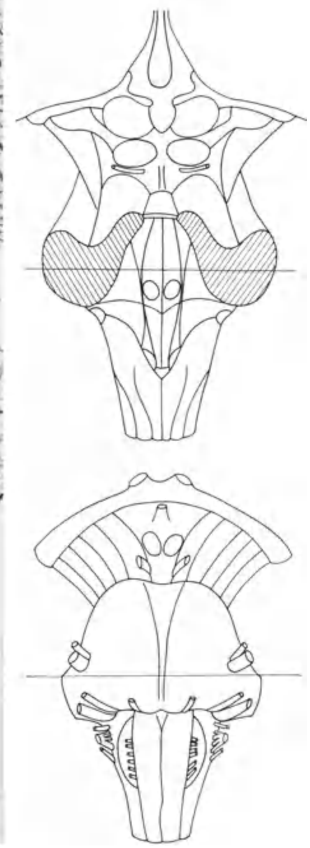


Fig. 127. Transverse Section of the Pons (middle part)
Bar, 2 mm

1, Medial longitudinal fasciculus; **2**, facial nerve; **3**, superior vestibular nucleus; **4**, motor trigeminal nucleus (inferior part); **5**, principal sensory trigeminal nucleus; **6**, trigeminal nerve (note the blood vessels reaching the sensory trigeminal nucleus through the fibers of the nerve (see p. 45). (This aspect is frequently found in the other cranial nerves, see Fig. 146); **7**, pontine nuclei; **8**, pontocerebellar fibers; **9**, corticospinal tract; **10**, nucleus reticularis tegmenti pontis; **11**, nucleus reticularis pontis caudalis; **12**, central tegmental tract; **13**, nucleus of the lateral lemniscus; **14**, medial lemniscus; **15**, lateral lemniscus
The *arrows* indicate an internal anterolateral pontine vein (see p. 42)

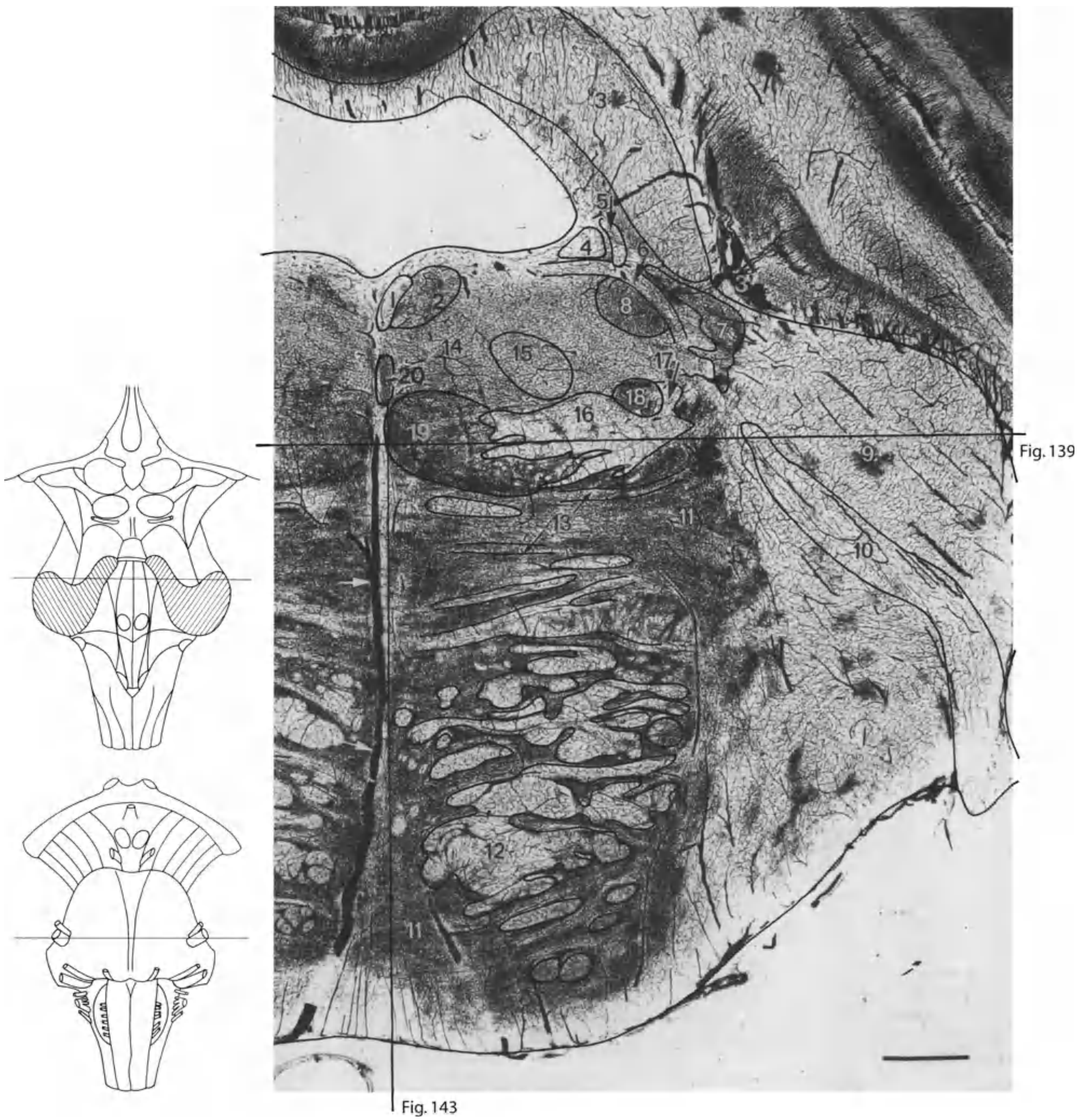
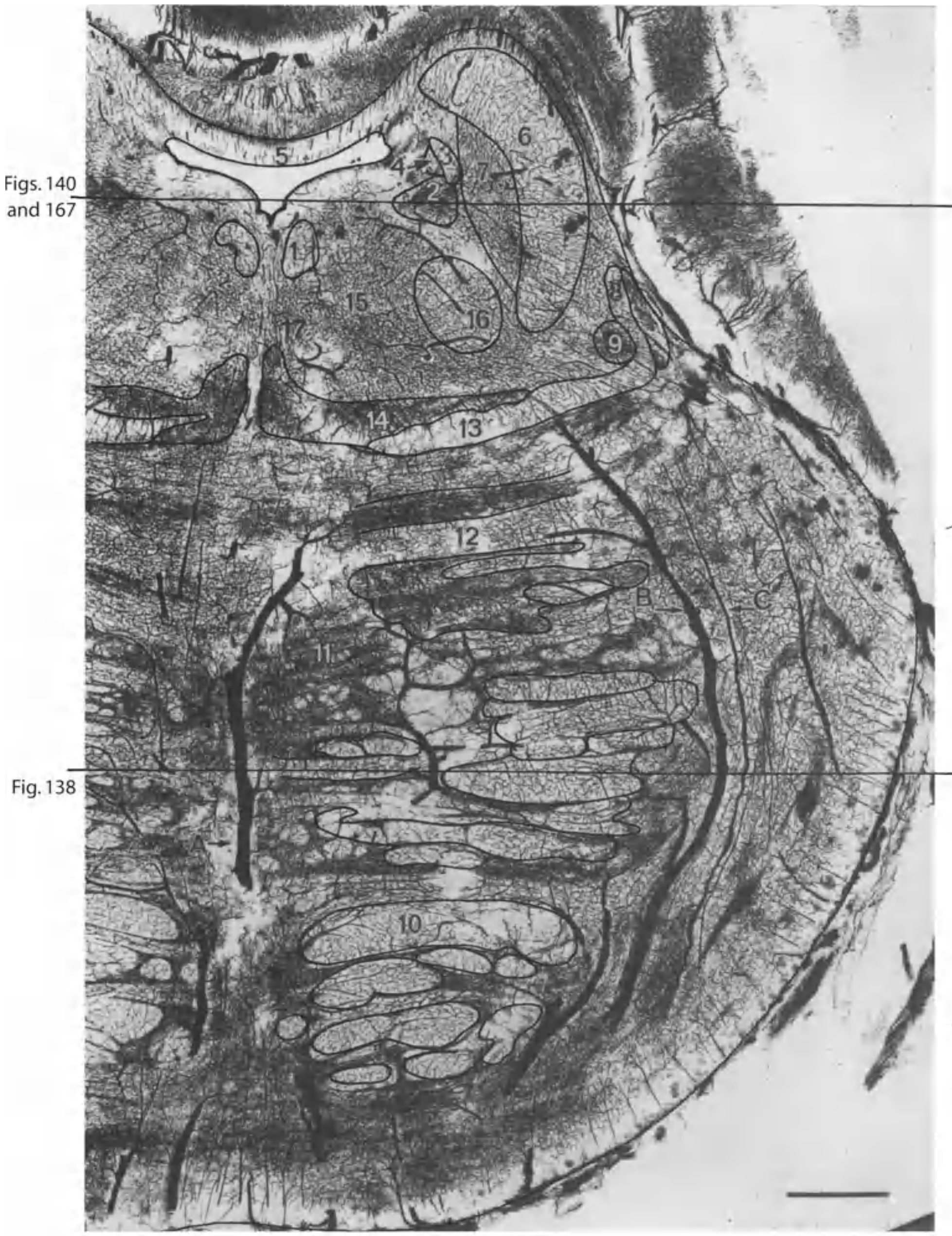


Fig. 128. Transverse Section of the Pons (middle part)
Bar, 2.2 mm

1, Medial longitudinal fasciculus; **2**, nucleus of the medial eminence (nucleus suprageniculatus); **3**, superior cerebellar peduncle; **3′**, parabrachial recess; **4**, superior vestibular nucleus; **5**, mesencephalic trigeminal nucleus and tract; **6**, facial nerve; **7**, principal sensory trigeminal nucleus; **8**, motor trigeminal nucleus; **9**, middle cerebellar peduncle; **10**, trigeminal nerve; **11**, pontine nuclei; **12**, corticospinal tract; **13**, pontocerebellar fibers; **14**, nucleus reticularis pontis caudalis; **15**, central tegmental tract; **16**, medial lemniscus; **17**, lateral lemniscus; **18**, nucleus of the lateral lemniscus; **19**, nucleus reticularis tegmenti pontis; **20**, nucleus raphes pontis
The *arrows* indicate an internal anteromedial pontine vein
The *lines* represent the planes of Figs. 139 and 143



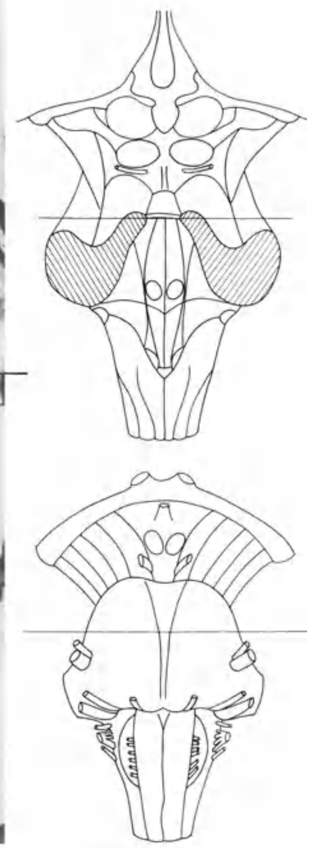


Fig. 129. Transverse Section of the Pons (superior part)
Bar, 2.2 mm

1, Medial longitudinal fasciculus; **2**, nucleus coeruleus; **3**, mesencephalic trigeminal tract; **4**, mesencephalic trigeminal nucleus; **5**, superior medullary velum; **6**, superior cerebellar peduncle; **7**, nucleus parabrachialis medialis; **8**, lateral lemniscus; **9**, nucleus of the lateral lemniscus; **10**, corticospinal tract; **11**, pontine nuclei; **12**, pontocerebellar fibres; **13**, medial lemniscus; **14**, nucleus reticularis tegmenti pontis; **15**, nucleus reticularis pontis oralis; **16**, central tegmental tract; **17**, nucleus reticularis centralis superior; **A**, internal anteromedial pontine vein; **B**, internal anterolateral pontine vein; **C**, internal anterolateral pontine artery
The *lines* represent the planes of Figs. 138, 140 and 167

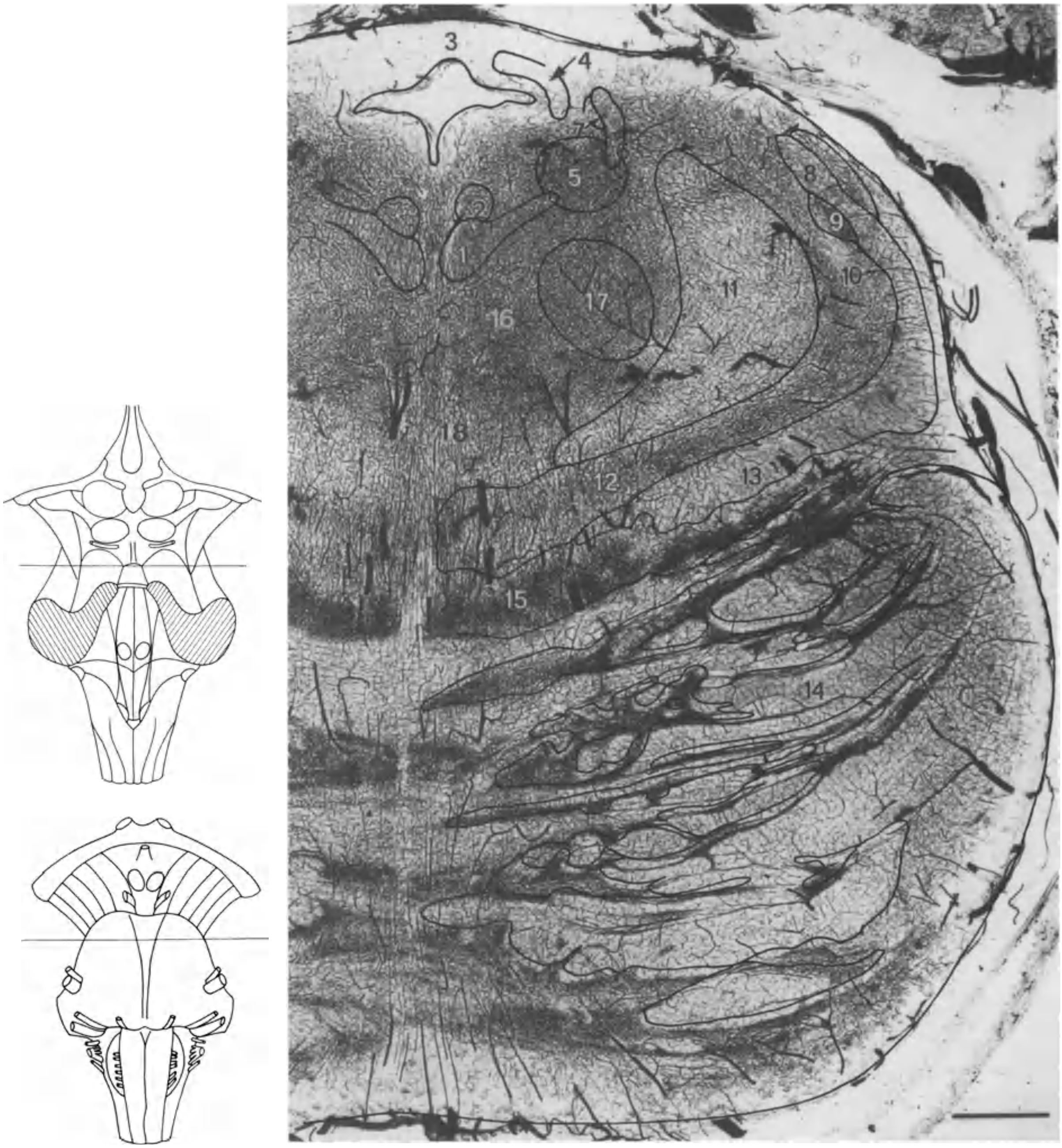


Fig. 130. Transverse Section of the Pons (superior part)
Bar, 2 mm

1, Medial longitudinal fasciculus; **2**, dorsal tegmental nucleus; **3**, superior medullary velum; **4**, trochlear nerve; **5**, nucleus coeruleus; **6**, mesencephalic trigeminal tract; **7**, mesencephalic trigeminal nucleus; **8**, lateral lemniscus; **9**, nucleus of the lateral lemniscus; **10**, nucleus parabrachialis lateralis; **11**, superior cerebellar peduncle (brachium conjunctivum); **12**, nucleus reticularis tegmenti pontis; **13**, medial lemniscus; **14**, corticospinal tract; **15**, pontine nuclei; **16**, nucleus reticularis pontis oralis; **17**, central tegmental tract; **18**, nucleus reticularis centralis superior

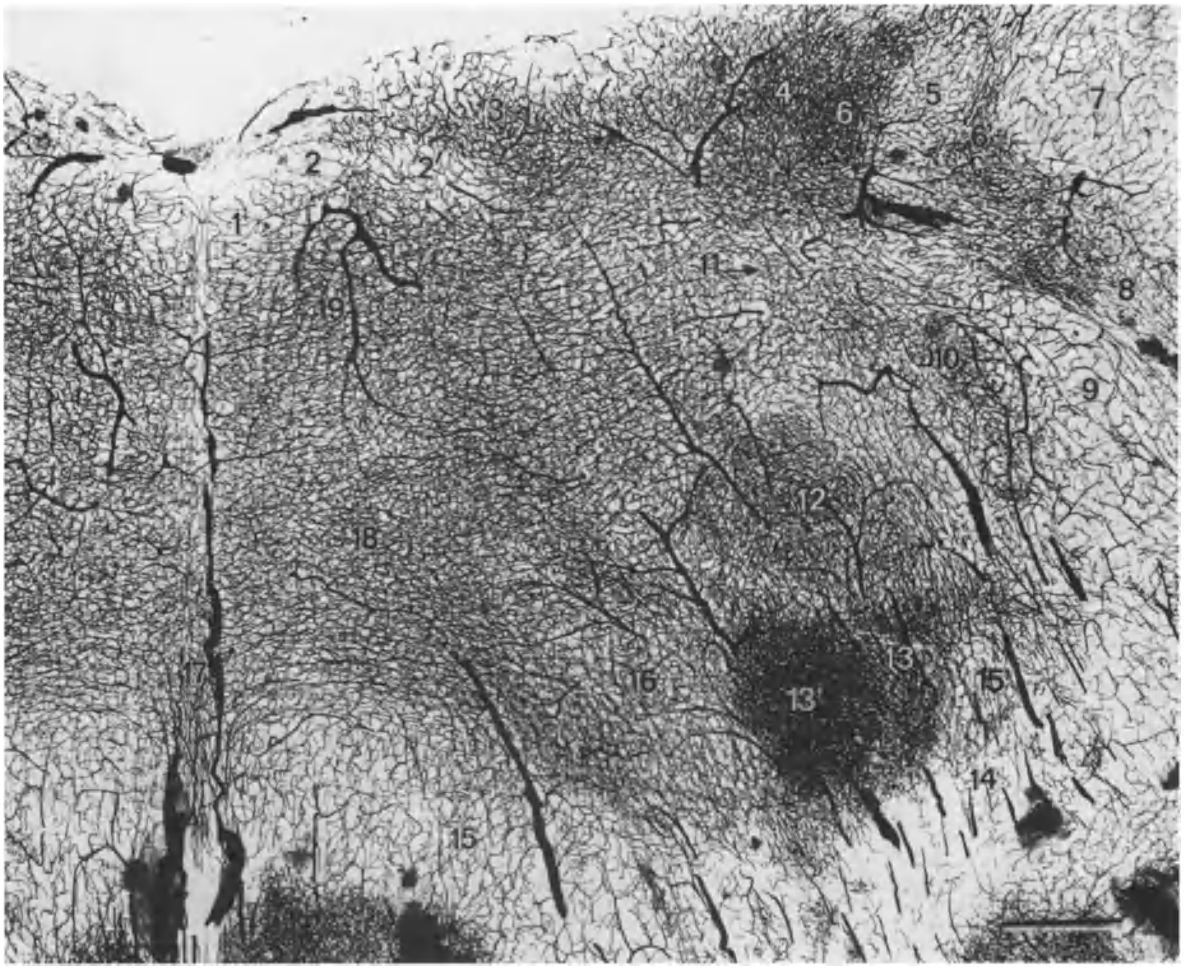
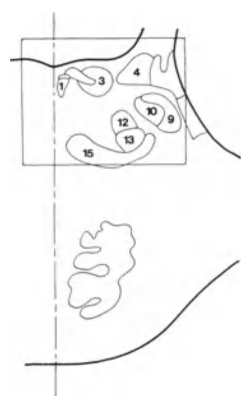


Fig. 131. Transverse Section of the Pontine Tegmentum at Caudal Level. **Bar, 1 mm**



1, Medial longitudinal fasciculus; **2**, genu of the facial nerve; **2'**, facial nerve; **3**, abducent nucleus; **4**, medial vestibular nucleus; **5**, descending vestibular root; **6**, lateral vestibular nucleus (medial part); **6'**, lateral vestibular nucleus (lateral part); **7**, inferior cerebellar peduncle; **8**, vestibulocochlear nerve; **9**, spinal trigeminal tract; **10**, spinal trigeminal nucleus (subnucleus oralis); **11**, nucleus ovalis (see p. 146); **12**, facial nucleus; **13**, superior olivary nucleus (lateral part); **13'**, superior olivary nucleus (medial part); **14**, pontomedullary sulcus and vessels belonging to the superior rami of the lateral medullary fossa (supplying the superior olivary and facial nuclei); **15**, medial lemniscus; **15'**, lateral lemniscus; **16**, central tegmental tract; **17**, nucleus raphes magnus; **18**, nucleus gigantocellularis; **19**, nucleus reticularis pontis caudalis

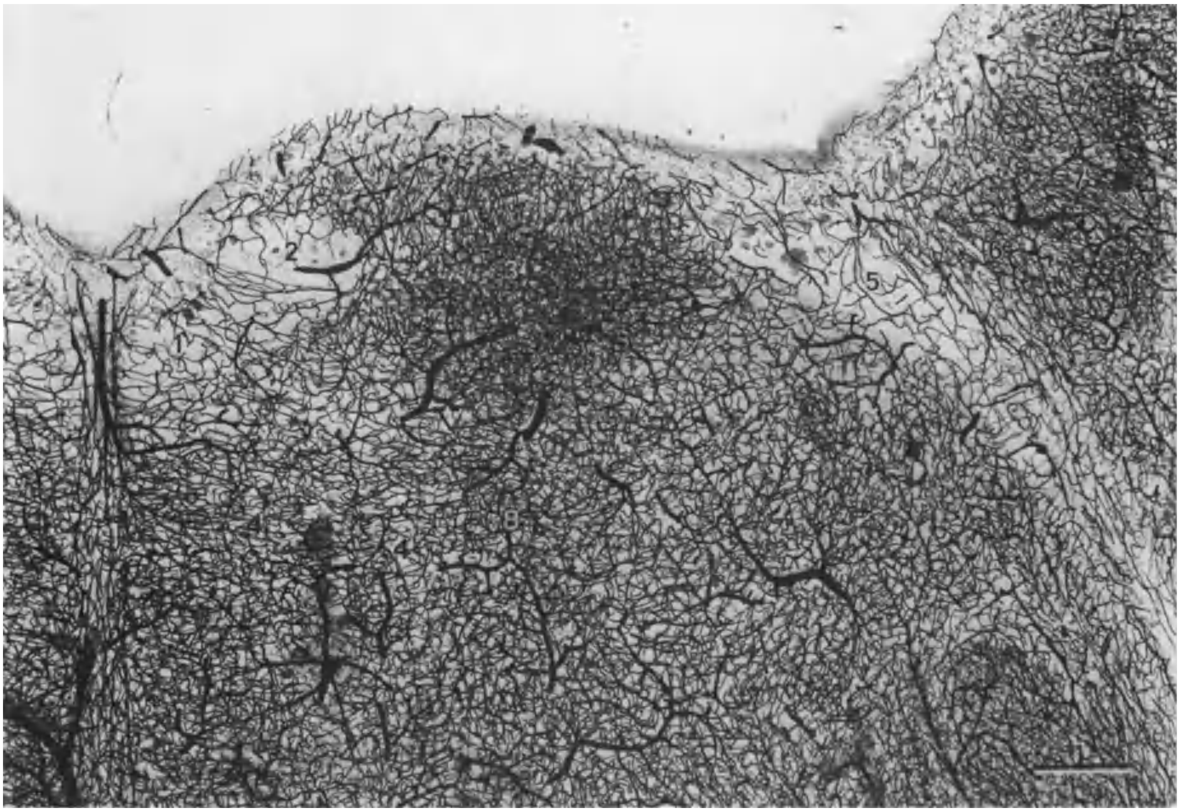
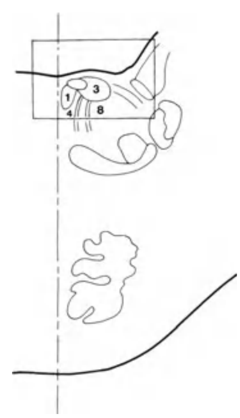


Fig. 132. Transverse Section of the Pontine Tegmentum at Caudal Level. **Bar, 740 µm**



1, Medial longitudinal fasciculus; **2**, genu of the facial nerve; **3**, abducent nucleus; **4**, abducent nerve; **5**, facial nerve; **6**, lateral vestibular nucleus; **7**, superior vestibular nucleus; **8**, nucleus reticularis pontis caudalis

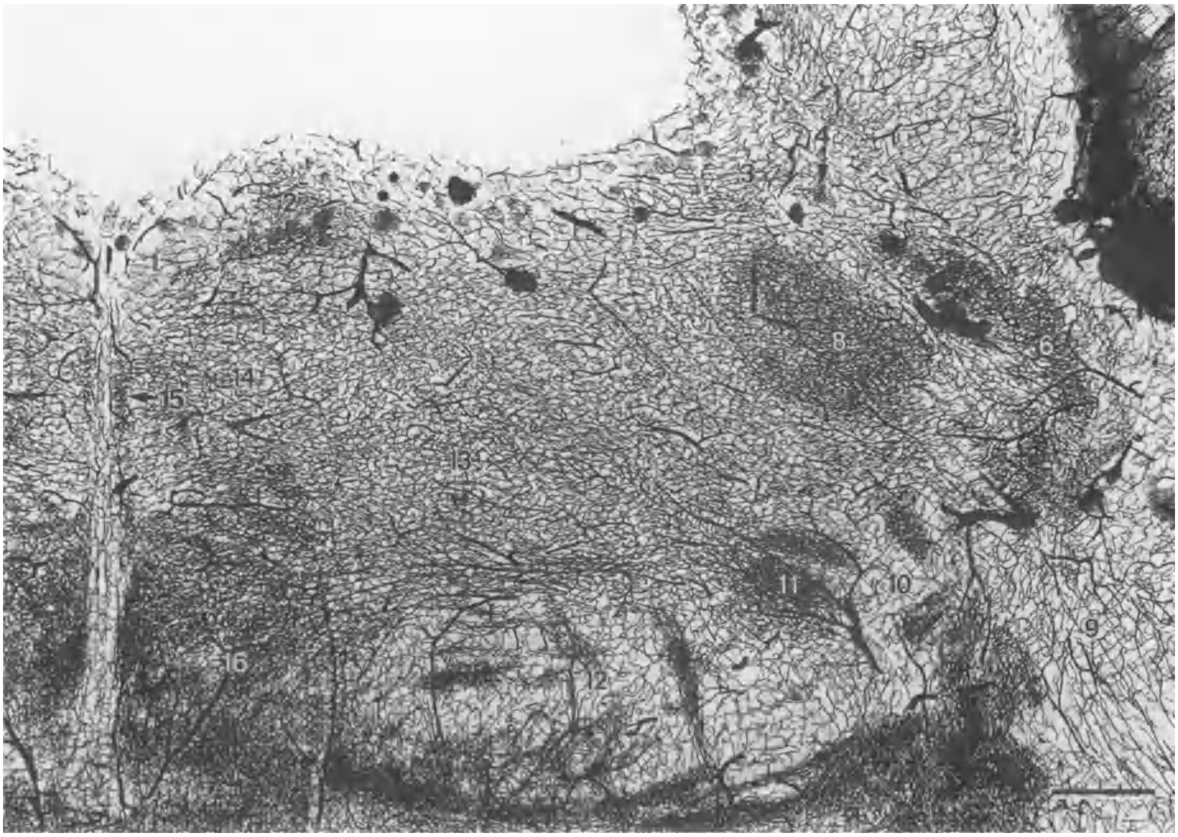
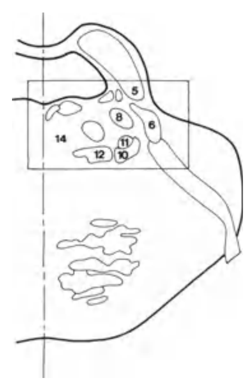


Fig. 133. Transverse Section of the Pontine Tegmentum at Intermediate Level. **Bar, 950 μm**



1, Medial longitudinal fasciculus; **2**, nucleus of the medial eminence (nucleus suprageniculatus); **3**, superior vestibular nucleus; **4**, mesencephalic trigeminal nucleus and tract; **5**, superior cerebellar peduncle; **6**, principal sensory trigeminal nucleus; **7**, facial nerve; **8**, motor trigeminal nucleus; **9**, trigeminal nerve; **10**, lateral lemniscus; **11**, nucleus of the lateral lemniscus; **12**, medial lemniscus; **13**, central tegmental tract; **14**, nucleus reticularis pontis caudalis; **15**, nucleus raphes pontis; **16**, nucleus reticularis tegmenti pontis

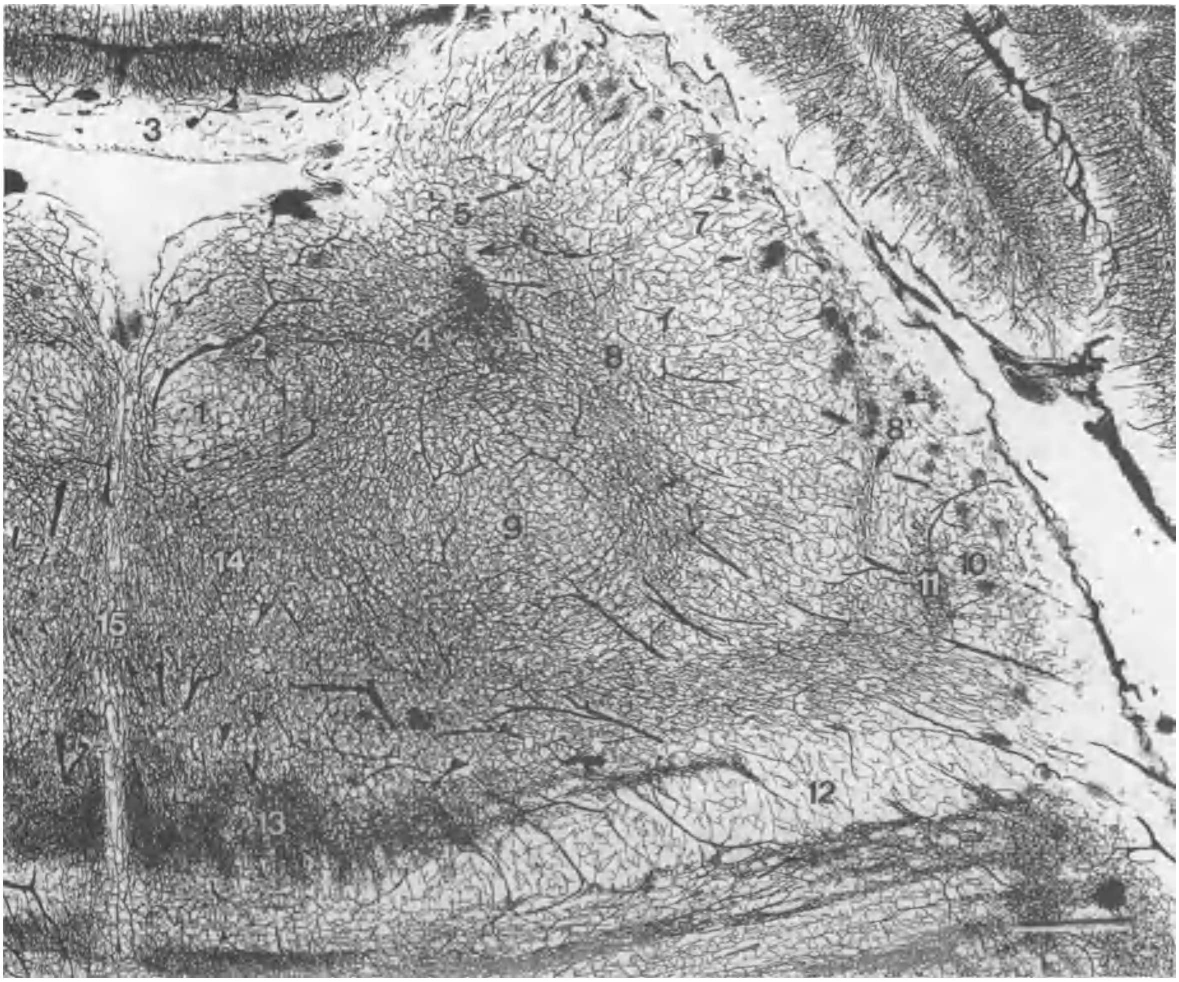
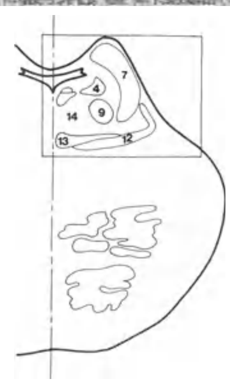


Fig. 134. Transverse Section of the Pontine Tegmentum (cranial level). **Bar, 1.3 mm**



1, Medial longitudinal fasciculus; **2**, dorsal tegmental nucleus (nucleus dorsalis tegmenti, Gudden); **3**, superior medullary velum; **4**, nucleus coeruleus; **5**, mesencephalic trigeminal nucleus; **6**, mesencephalic trigeminal tract; **7**, superior cerebellar peduncle (brachium conjunctivum); **8**, nucleus parabrachialis medialis; **8′**, nucleus parabrachialis lateralis; **9**, central tegmental tract; **10**, lateral lemniscus; **11**, nucleus of the lateral lemniscus; **12**, medial lemniscus; **13**, nucleus reticularis tegmenti pontis; **14**, nucleus reticularis pontis oralis; **15**, nucleus reticularis centralis superior

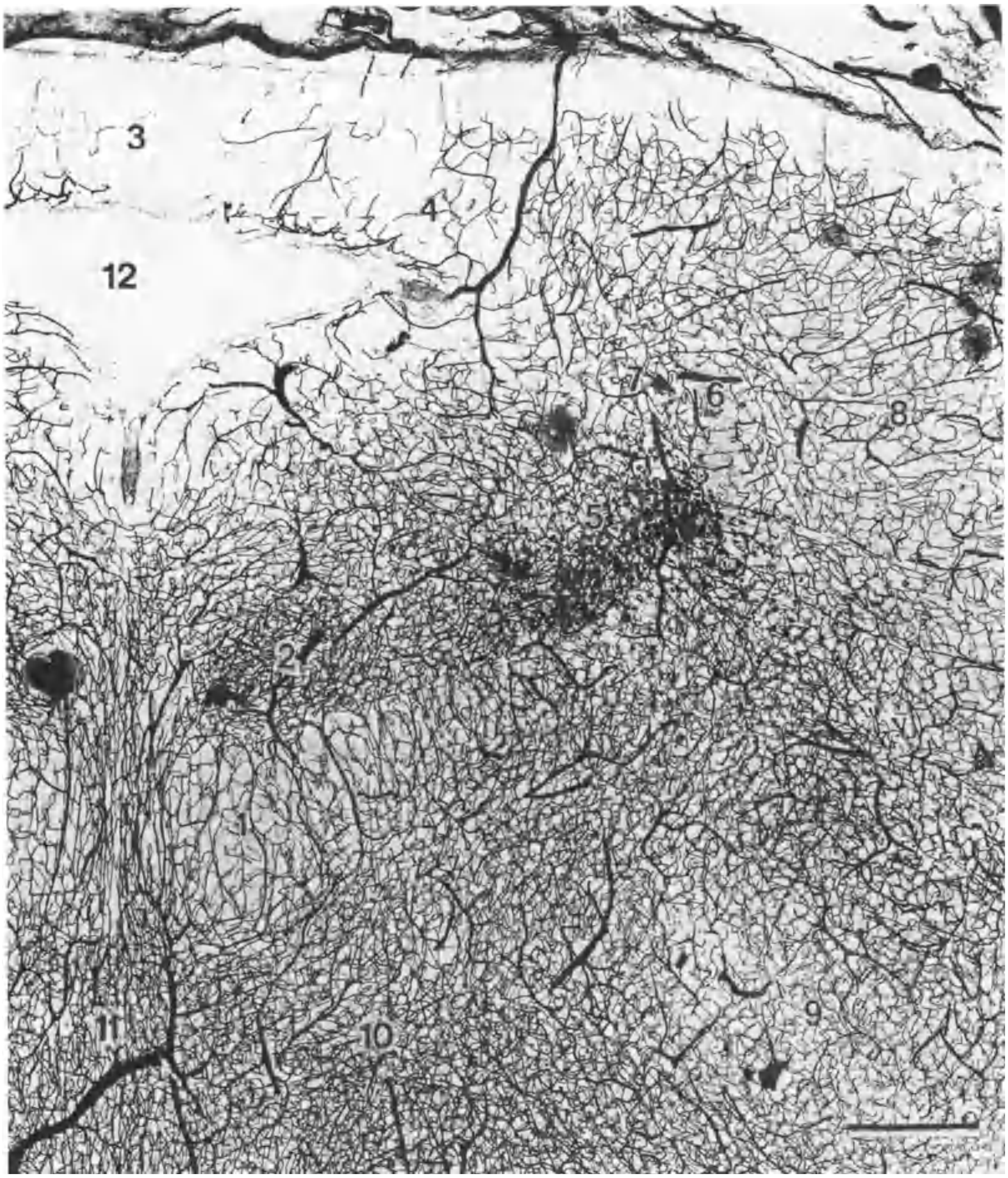
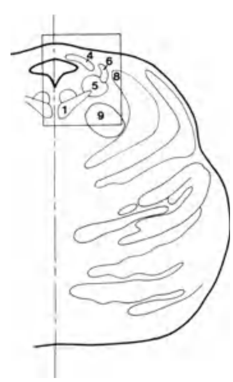


Fig. 135a,b. Transverse Section of the Pontine Tegmentum of cranial level. **a** Bar, 660 µm



1, Medial longitudinal fasciculus; **2**, dorsal tegmental nucleus (nucleus dorsalis tegmenti, Gudden); **3**, superior medullary velum; **4**, trochlear nerve; **5**, nucleus coeruleus; **6**, mesencephalic trigeminal tract; **7**, mesencephalic trigeminal nucleus; **8**, superior cerebellar peduncle; **9**, central tegmental tract; **10**, nucleus reticularis pontis oralis; **11**, nucleus reticularis centralis superior; **12**, fourth ventricle (upper part)

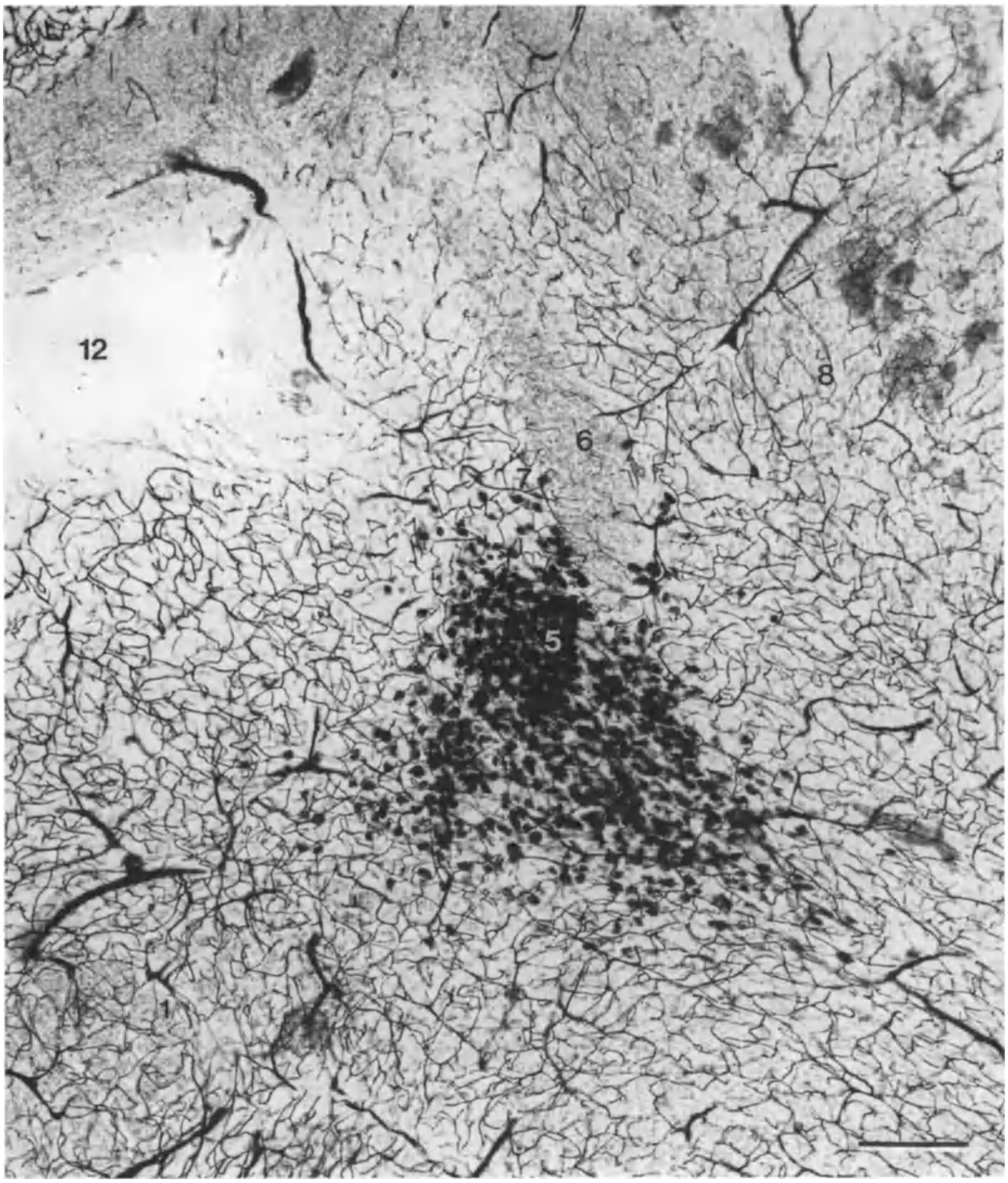


Fig. 135b. Bar, 330 μm

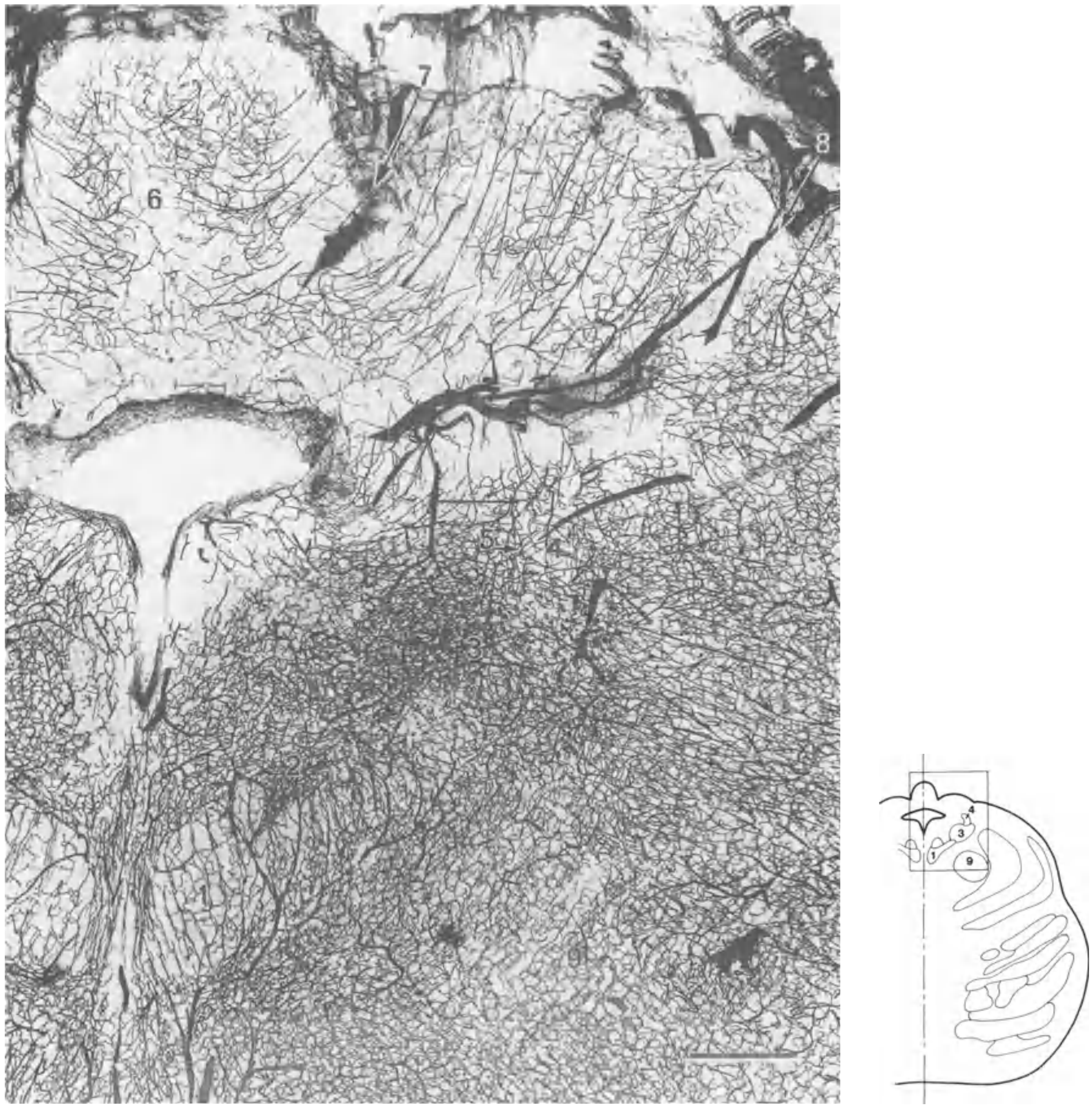


Fig. 136. Transverse Section of the Pontine Tegmentum (cranial level). **Bar, 860 µm**

1, Medial longitudinal fasciculus; **2**, accessory trochlear nucleus (see p. 148); **3**, nucleus coeruleus; **4**, mesencephalic trigeminal tract; **5**, mesencephalic trigeminal nucleus; **6**, frenulum veli; **7**, recess of the frenulum veli; **8**, infracollicular recess and its blood vessels (see p. 76); **9**, central tegmental tract

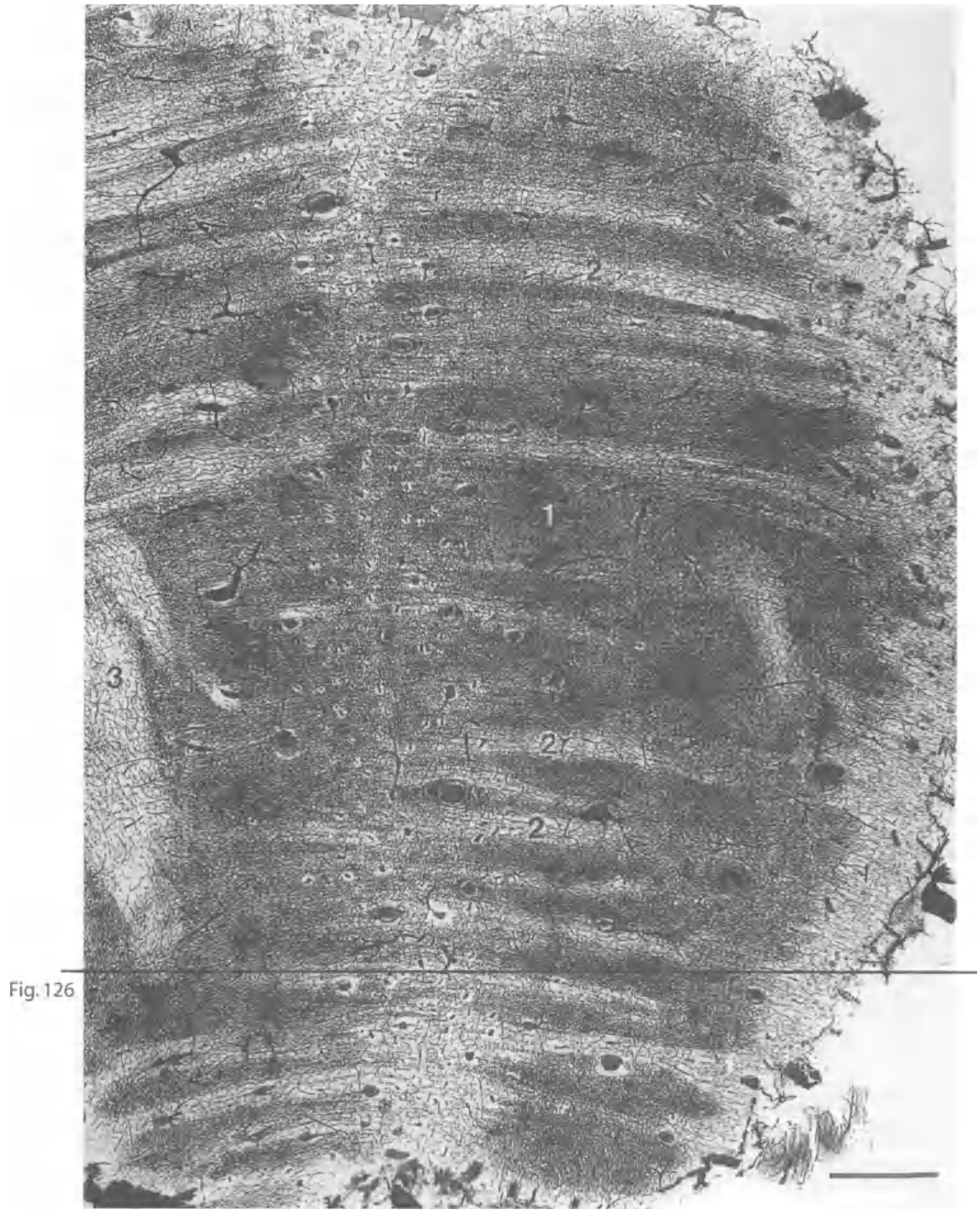


Fig. 137. Coronal Section of the Pons (in the plane indicated in Fig. 126). **Bar, 2.2 mm**

1, Pontine nuclei; 2, pontocerebellar fibers; 3, corticospinal tract

Fig. 138. Coronal Section of the Pons (in the plane indicated in Fig. 129). **Bar, 2.2 mm**

1, Corticospinal tract; **2**, crus cerebri; **3**, interpeduncular fossa; **4**, pontine nuclei; **5**, pontocerebellar fibers; **A**, internal anteromedial pontine blood vessels (see p. 41); **B**, internal anterolateral pontine blood vessels (see p. 42)

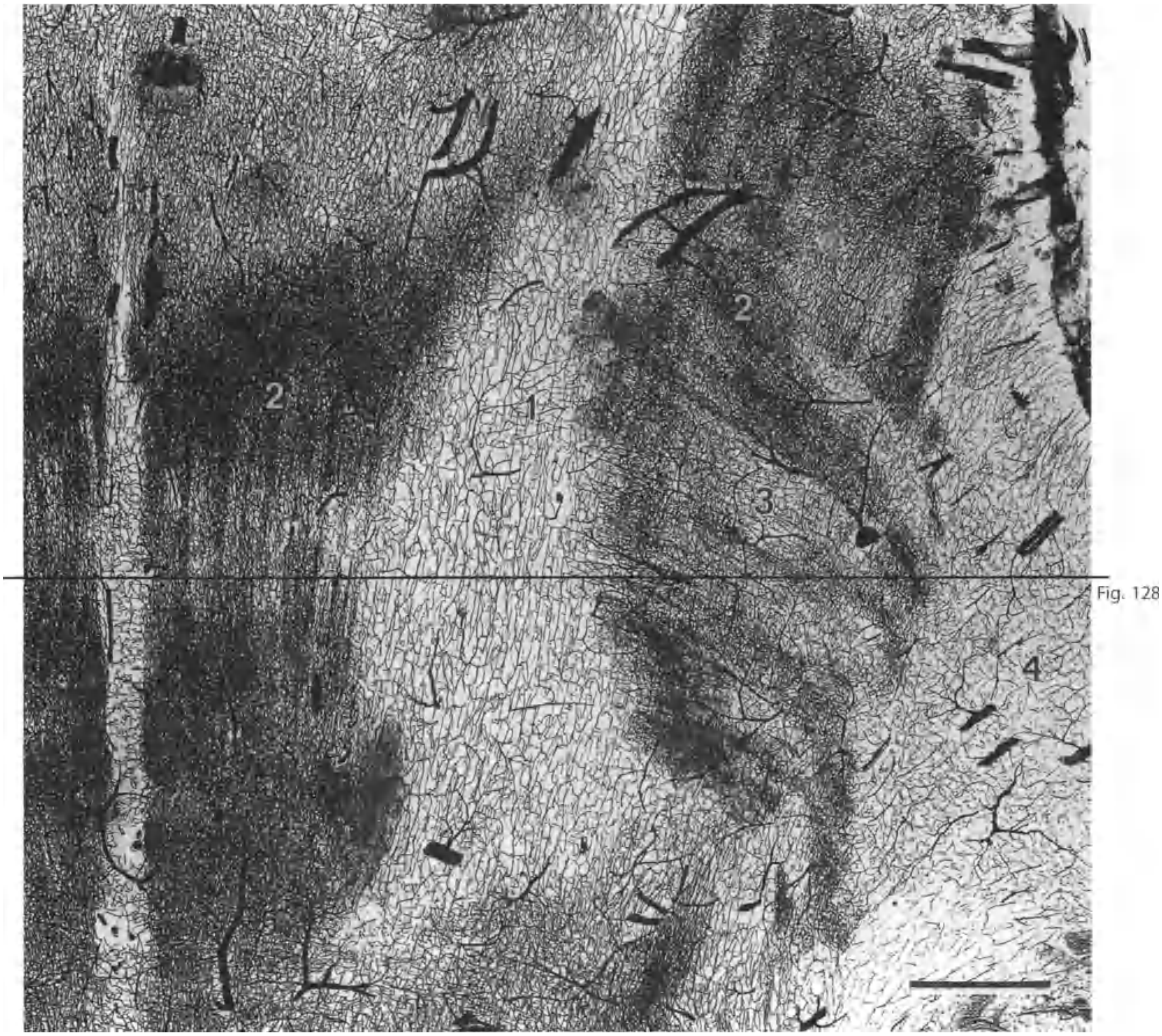


Fig. 139. Coronal Section of the Pons (in the plane indicated in Fig. 128). **Bar, 1.8 mm**

1, Medial lemniscus; **2**, nucleus reticularis tegmenti pontis; **3**, pontocerebellar fibers; **4**, middle cerebellar peduncle (brachium pontis)

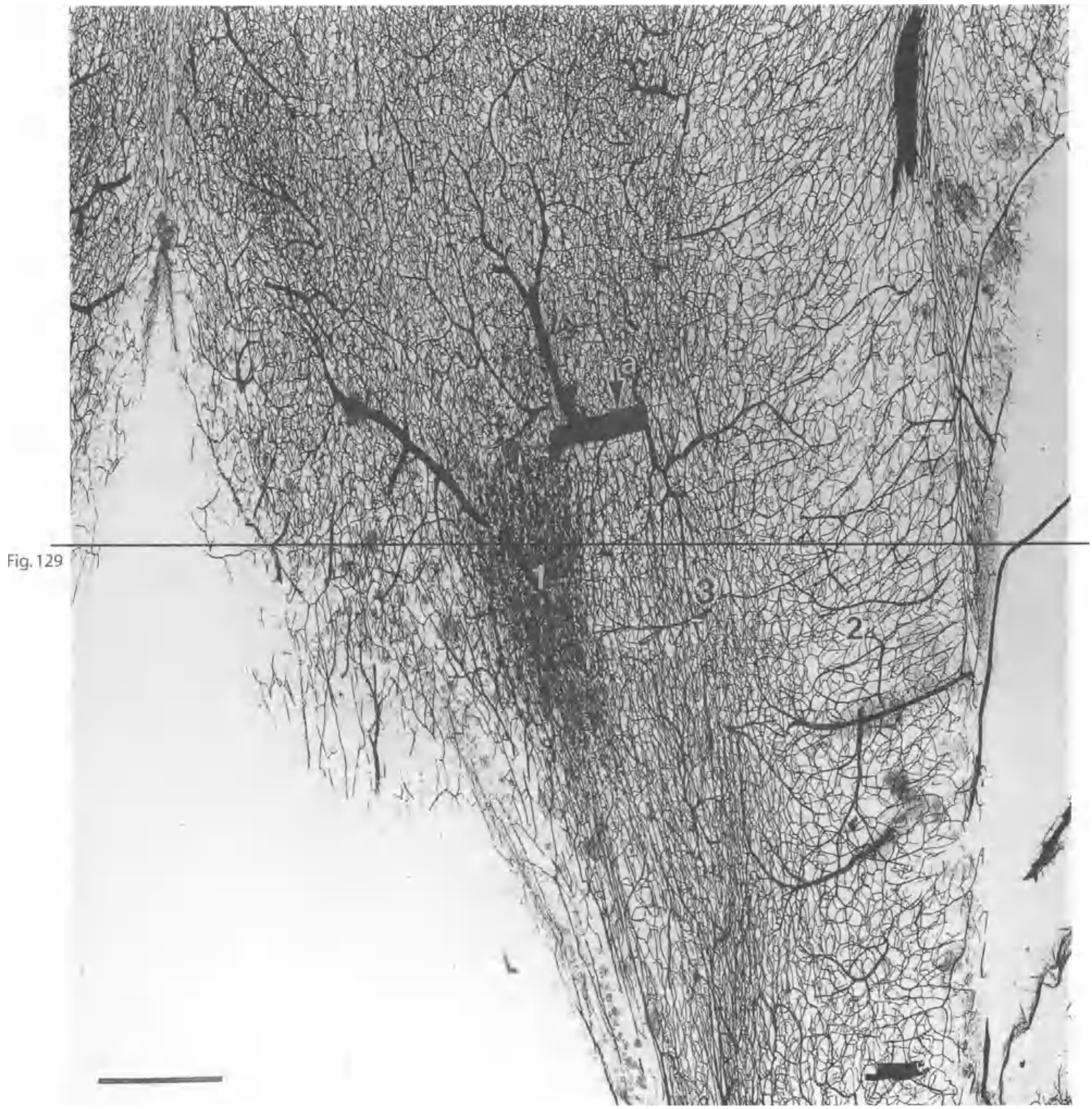


Fig. 140. Coronal Section of the Pons (in the plane indicated in Fig. 129). Bar, 1.2 mm

1, Nucleus coeruleus; 2, superior cerebellar peduncle (brachium conjunctivum); 3, nucleus parabrachialis medialis; a, vein of the locus coeruleus (see p. 43)

Fig. 141. Sagittal Section of the Pons and Cerebellum to Show the Site of the Nucleus Coeruleus. **Bar, 2 mm**

1, Nucleus coeruleus; **2**, superior cerebellar peduncle (brachium conjunctivum); **3**, inferior colliculus; **4**, superior vermis (central lobule); **5**, fastigial nucleus; **6**, fourth ventricle

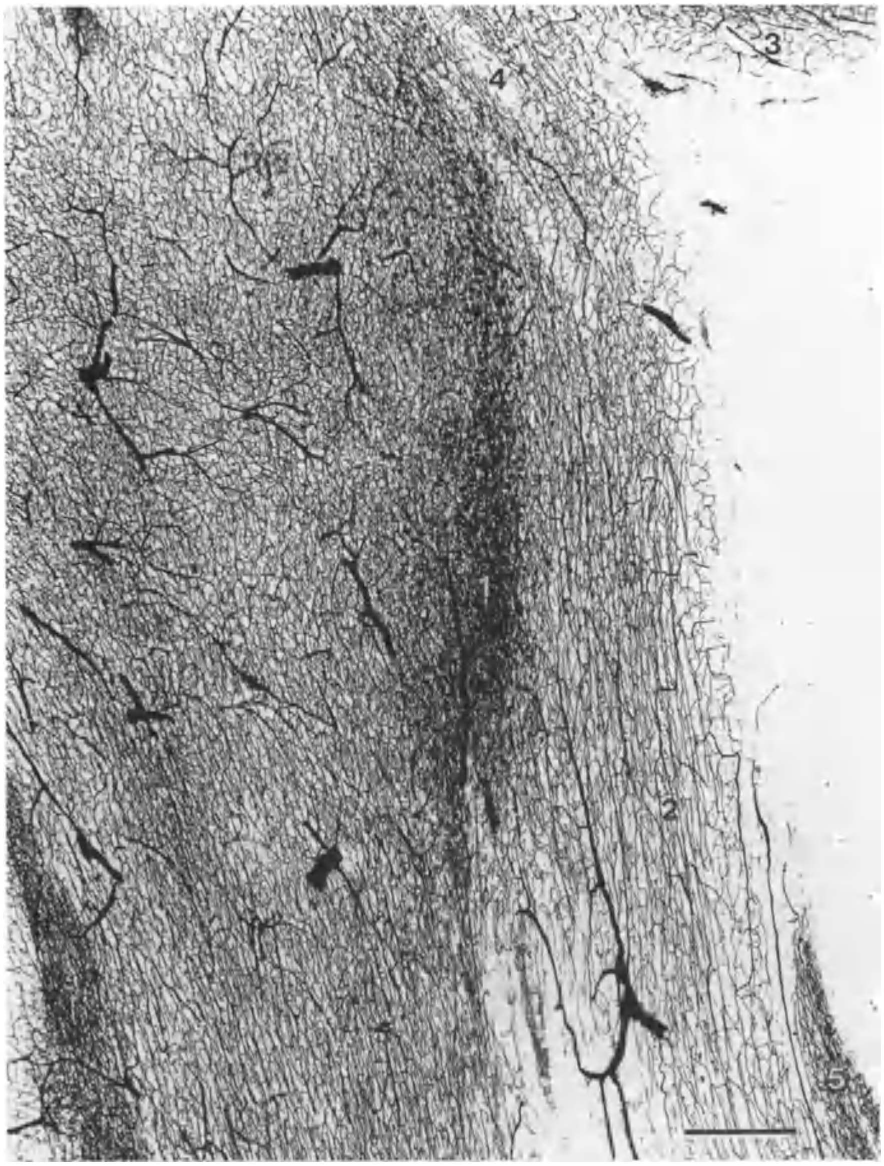


Fig. 142. Sagittal Section of the Pons. Bar, 950 µm

1, Nucleus coeruleus; 2, superior cerebellar peduncle; 3, inferior colliculus; 4, trochlear nerve; 5, lingula of vermis

Fig. 143. Sagittal (median) Section of the Pons (in the plane indicated in Fig. 128 to show the general orientation of vessels supplying the tegmental part of the pons). **Bar, 2.2 mm**

1, Interpeduncular fossa; **2**, arteries and veins belonging to the inferior pedicle of the interpeduncular fossa with their curved downward route toward the superior pontine tegmentum (**8'**) (see Fig. 28d); **3**, internal principal anteromedial vein of the pons; **4**, pontine nuclei; **5**, foramen caecum; **6**, arteries and veins of the foramen caecum (note their curved upward path toward the inferior pontine tegmentum (**8''**) see Fig. 28d; **7**, fourth ventricle; **8**, pontine tegmentum (middle part); **8'**, superior pontine tegmentum; **8''**, inferior pontine tegmentum; **9**, basilar part of the pons; **10**, medulla; **11**, arcuate nucleus

Fig. 144. Sagittal (Paramedian) Section of the Pons (in the plane indicated in Fig. 126). **Bar, 1.2 mm**

1, Corticospinal tract; **2**, pontine nuclei; **3**, pontocerebellar fibers; **4**, medial lemniscus

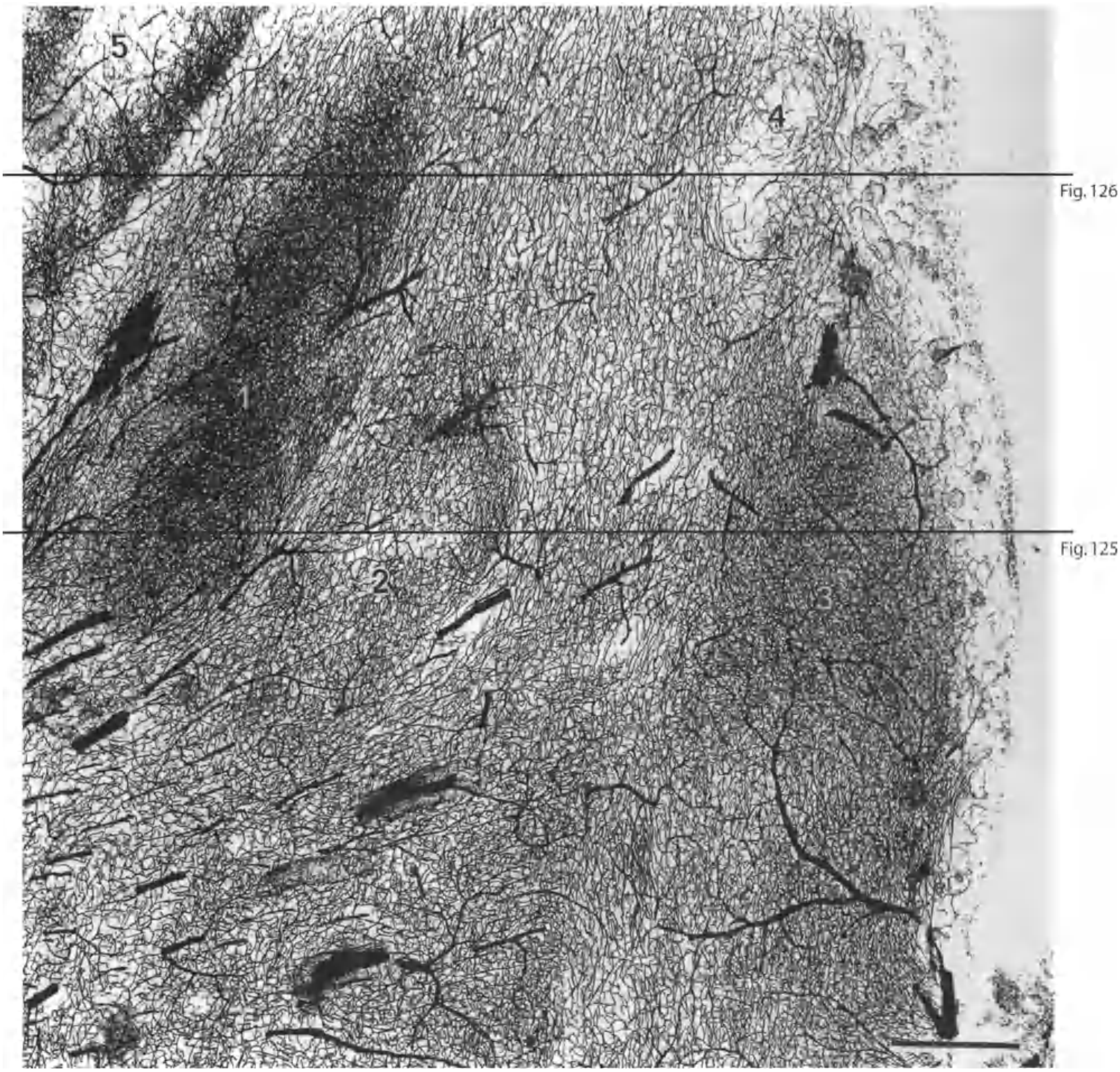


Fig. 145. Sagittal (Paramedian) Section of the Pons (in the plane indicated in Figs. 125 and 126). **Bar, 1 mm**

1, Superior olivary nucleus; **2**, facial nucleus; **3**, medial vestibular nucleus; **4**, facial nerve; **5**, lateral lemniscus

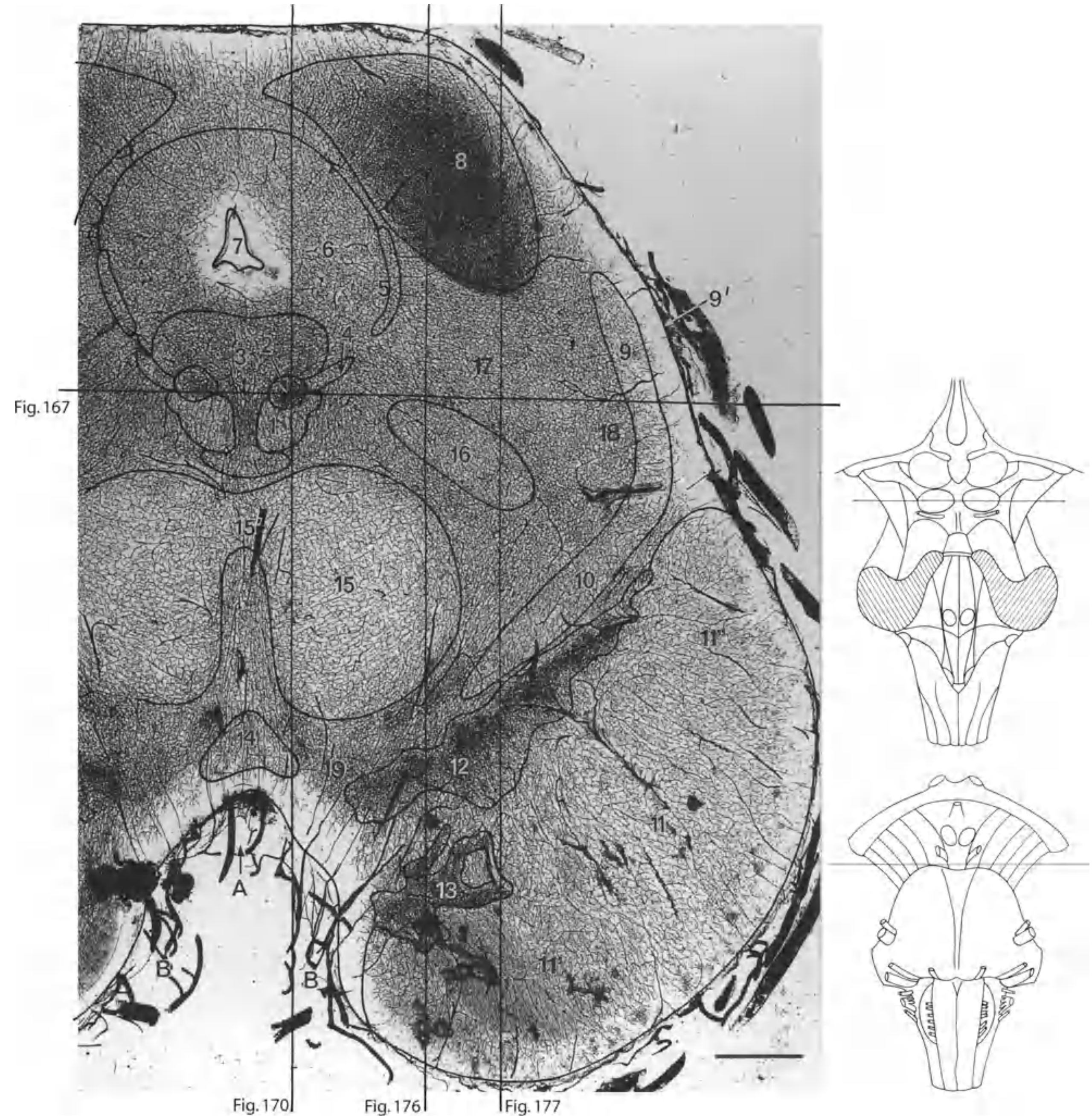


Fig. 146. Transverse Section of the Mesencephalon (inferior level). **Bar, 2 mm**

1, Medial longitudinal fasciculus; **2**, trochlear nucleus; **3**, dorsal nucleus of the raphé; **4**, trochlear nerve; **5**, mesencephalic trigeminal tract; **6**, periaqueductal grey matter; **7**, cerebral aqueduct; **8**, inferior colliculus; **9**, lateral lemniscus; **9′**, lateral surface of the mesencephalon (lemniscal trigone); **10**, medial lemniscus; **11**, crus cerebri (corticospinal tract); **11′**, frontopontine tract; **11″**, parietotemporopontine tract; **12**, substantia nigra (pars compacta); **13**, pontine nuclei; **14**, interpeduncular nucleus; **15**, superior cerebellar peduncle (brachium conjunctivum); **15′**, decussation of the superior cerebellar peduncles; **16**, central tegmental tract; **17**, nucleus reticularis cuneiformis; **18**, nucleus reticularis pedunculopontinus; **19**, ventral tegmental area. Intermediate pedicle of vessels of the interpeduncular fossa (see p. 53): **A**, median group of rami; **B**, lateral groups of rami penetrating in the nervous tissue through the fibers of the oculomotor nerve
The *lines* represent the planes of Figs. 167, 170, 176, 177)

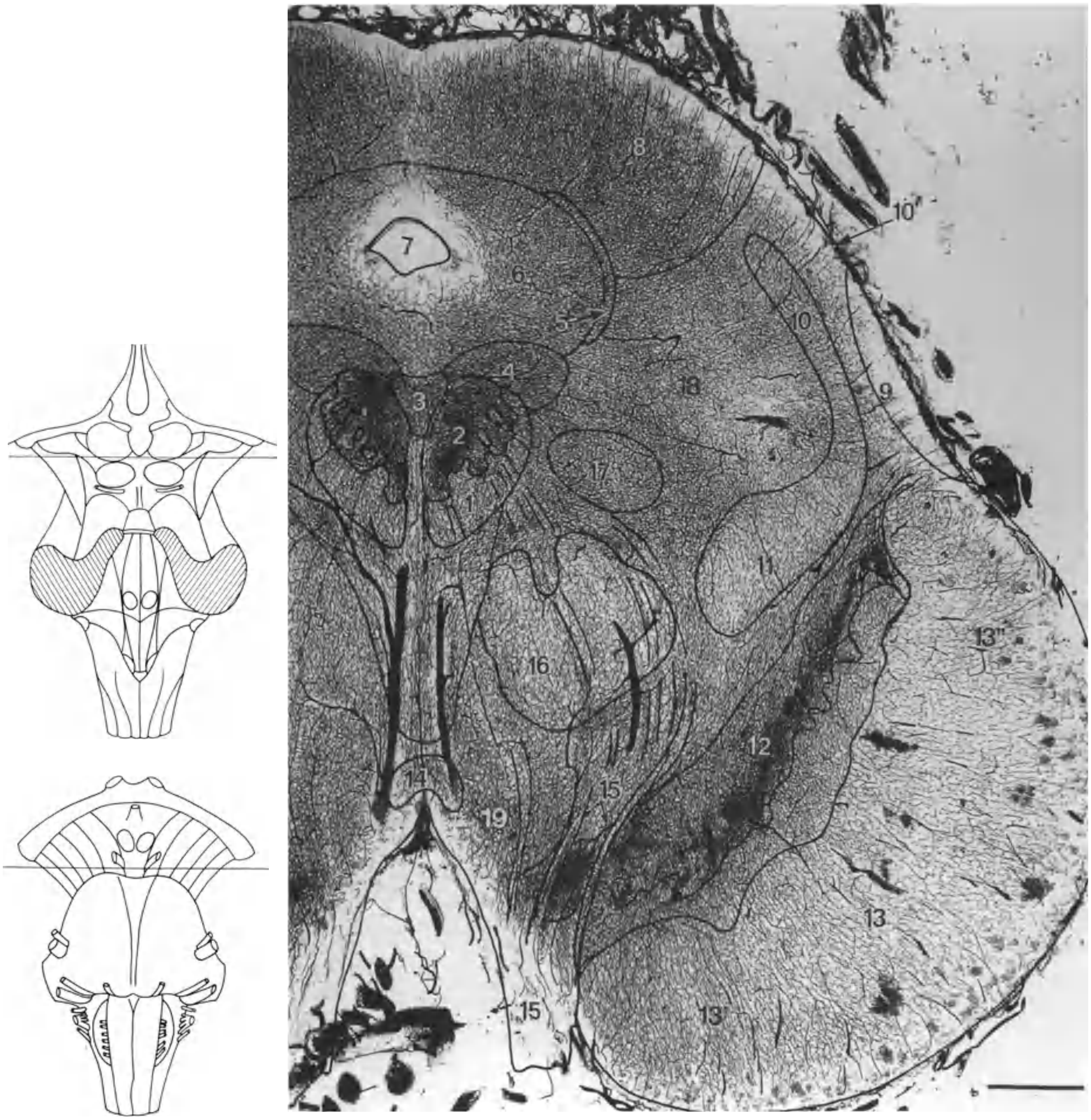


Fig. 147. Transverse Section of the Mesencephalon (inferior level). Bar, 2 mm

1, Medial longitudinal fasciculus; 2, main oculomotor nucleus; 3, caudal central oculomotor nucleus; 4, dorsal nucleus of the raphé; 5, mesencephalic trigeminal tract; 6, periaqueductal grey matter; 7, cerebral aqueduct; 8, superior colliculus; 9, inferior collicular brachium; 10, lateral lemniscus; 10', lateral surface of the mesencephalon (lemniscal trigone); 11, medial lemniscus; 12, substantia nigra (pars compacta); 13, crus cerebri (corticospinal tract); 13', frontopontine tract; 13'', parietotemporopontine tract; 14, interpeduncular nucleus; 15, oculomotor nerve; 16, superior cerebellar peduncle (brachium conjunctivum); 17, central tegmental tract; 18, nucleus reticularis cuneiformis; 19, ventral tegmental area

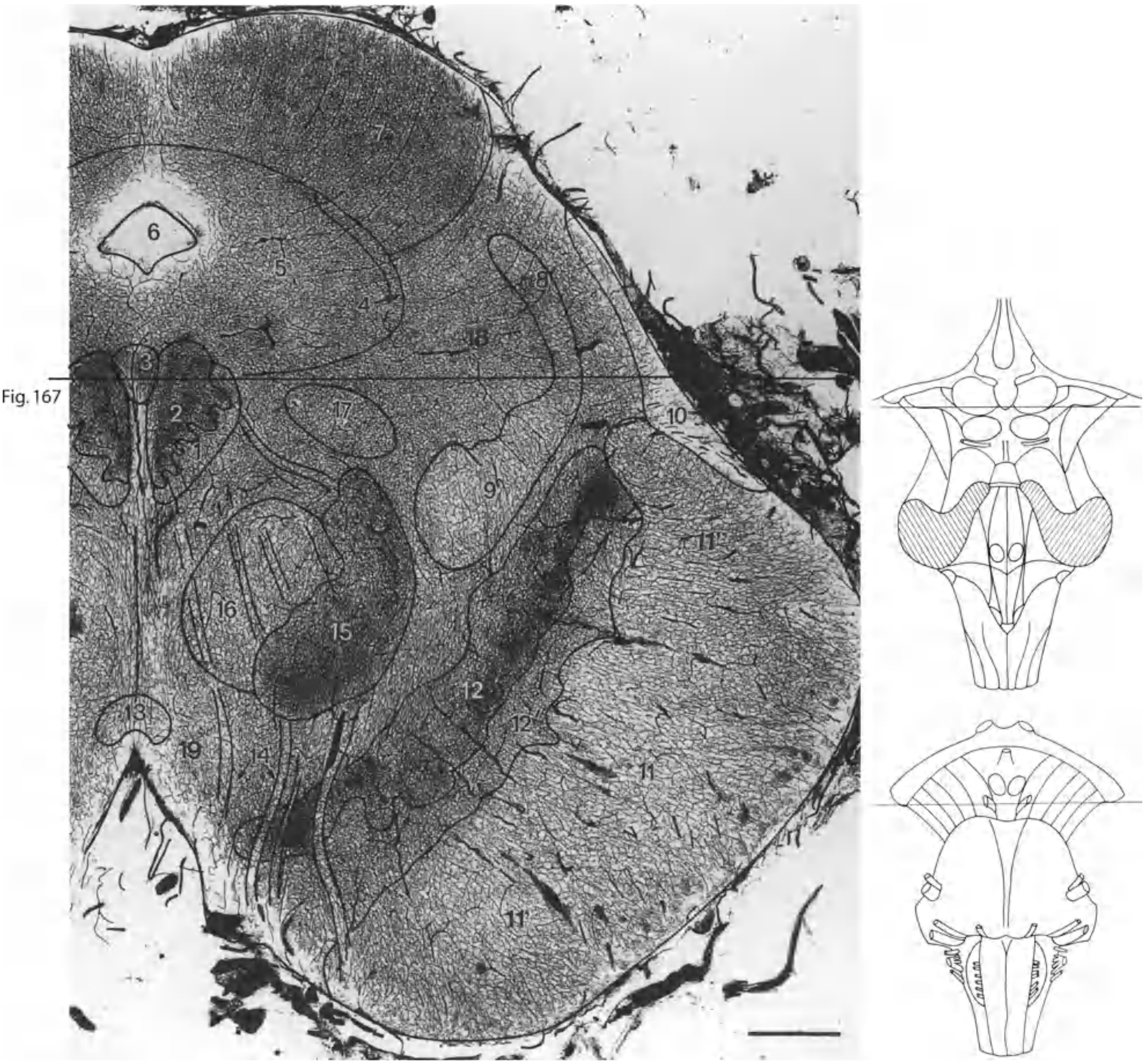


Fig. 148. Transverse Section of the Mesencephalon (intermediate level). Bar, 2.2 mm

1, Medial longitudinal fasciculus; **2**, main oculomotor nucleus; **3**, caudal central oculomotor nucleus; **4**, mesencephalic trigeminal tract; **5**, periaqueductal grey matter; **6**, cerebral aqueduct; **7**, superior colliculus; **8**, lateral lemniscus; **9**, medial lemniscus; **10**, inferior collicular brachium; **11**, crus cerebri (corticospinal tract); **11′**, frontopontine tract; **11″**, parietotemporopontine tract; **12**, substantia nigra (pars compacta); **12′**, substantia nigra (pars reticulata); **13**, interpeduncular nucleus; **14**, oculomotor nerve; **15**, red nucleus; **16**, superior cerebellar peduncle; **17**, central tegmental tract; **18**, nucleus reticularis cuneiformis; **19**, ventral tegmental area

The *line* represents the plane of Fig. 167

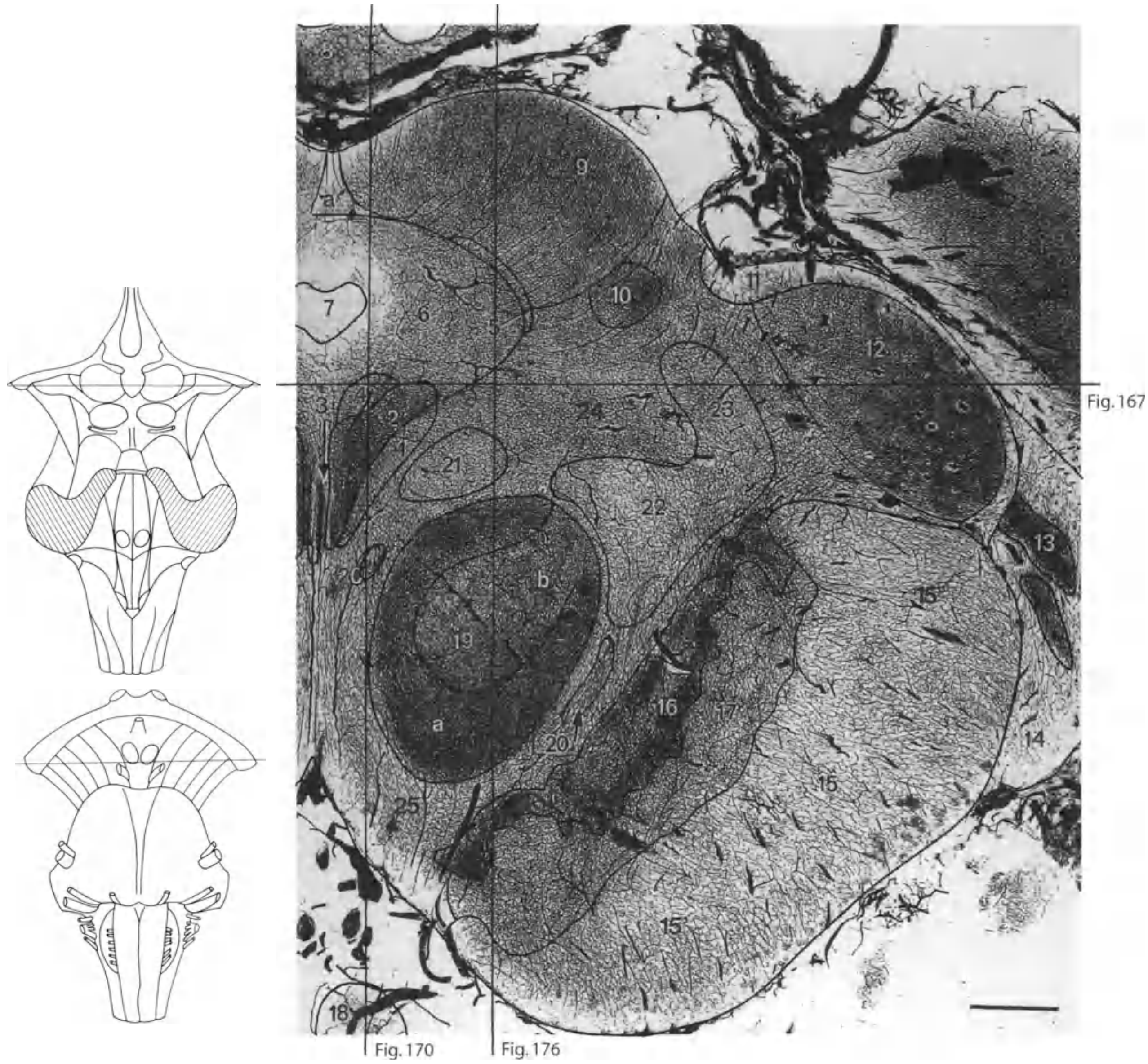


Fig. 149. Transverse Section of the Mesencephalon (middle part). **Bar, 2.2 mm**

1, Medial longitudinal fasciculus; **2**, main oculomotor nucleus; **3**, central oculomotor nucleus (of Perlia); **4**, accessory oculomotor nucleus (of Edinger-Westphal); **5**, mesencephalic trigeminal tract; **6**, periaqueductal grey matter; **7**, cerebral aqueduct; **8**, pineal gland; **9**, superior colliculus; **10**, nucleus intracuneiformis ; **11**, inferior collicular brachium; **12**, medial geniculate body; **13**, lateral geniculate body; **14**, optic tract; **15**, crus cerebri: corticospinal tract; **15'**, frontopontine tract; **15"**, parietotemporopontine tract; **16**, substantia nigra (pars compacta); **17**, substantia nigra (pars reticulata); **18**, mamillary body; **19**, red nucleus; **a**, densely vascularized part; **b**, poorly vascularized part; **20**, nucleus intracapsularis; **21**, central tegmental tract; **22**, medial lemniscus; **23**, lateral lemniscus; **24**, nucleus reticularis cuneiformis; **25**, ventral tegmental area; **a**, middle central collicular vein (see p. 55)

The *lines* represent the planes of Figs. 167, 170, 176

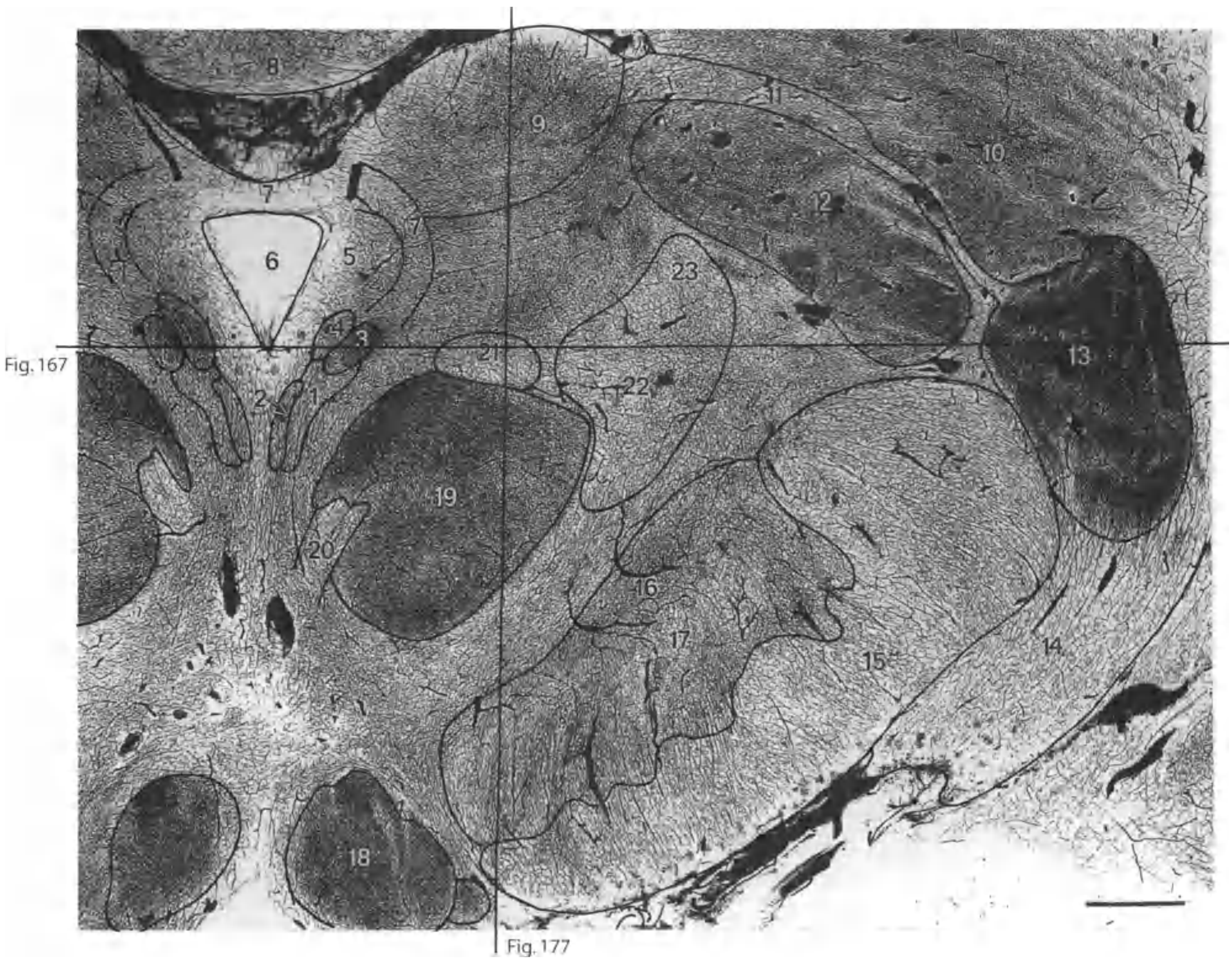
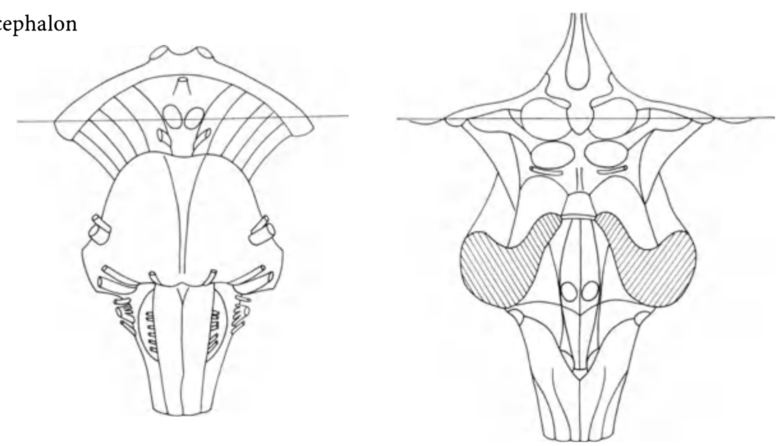
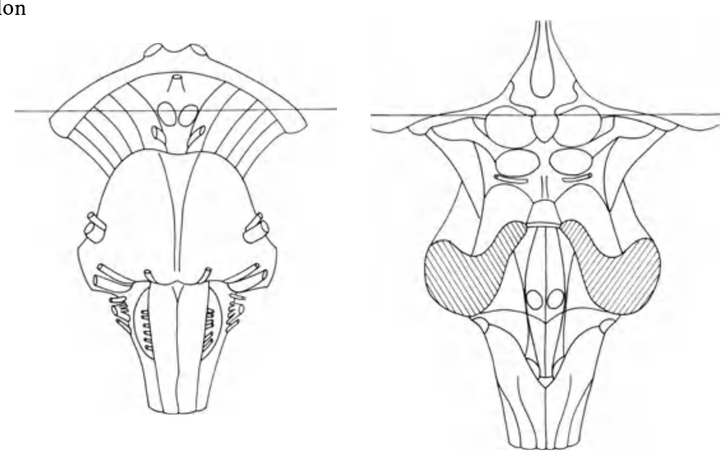


Fig. 150. Transverse Section of the Mesencephalon (superior part). **Bar, 2.5 mm**



1, Medial longitudinal fasciculus; **2**, accessory oculomotor nucleus (Edinger-Westphal); **3**, interstitial nucleus (Cajal); **4**, nucleus of the posterior commissure (Darkschewitsch); **5**, periaqueductal grey matter; **6**, cerebral aqueduct; **7**, posterior commissure; **8**, pineal gland; **9**, superior colliculus; **10**, pulvinar; **11**, superior collicular brachium; **12**, medial geniculate body; **13**, lateral geniculate body; **14**, optic tract; **15**, crus cerebri; **16**, substantia nigra (pars compacta); **17**, substantia nigra (pars reticulata); **18**, mamillary body; **19**, red nucleus; **20**, habenulopeduncular tract; **21**, central tegmental tract; **22**, medial lemniscus; **23**, lateral lemniscus
The *lines* represent the planes of Figs. 167 and 177

Fig. 151. Transverse Section of the Mesencephalon (mesencephalodiencephalic junction)
Bar, 2.8 mm



1, Red nucleus; **2**, habenulopeduncular tract; **3**, interstitial nucleus (Cajal); **4**, nucleus of the posterior commissure (Darkschewitsch); **5**, posterior commissure; **6**, pineal gland; **7**, superior colliculus; **8**, lateral geniculate body; **9**, crus cerebri; **10**, optic tract; **11**, subthalamic nucleus; **12**, medial lemniscus; **13**, mamillary body; **14**, medial geniculate body; **15**, pretectal area; **16**, pulvinar

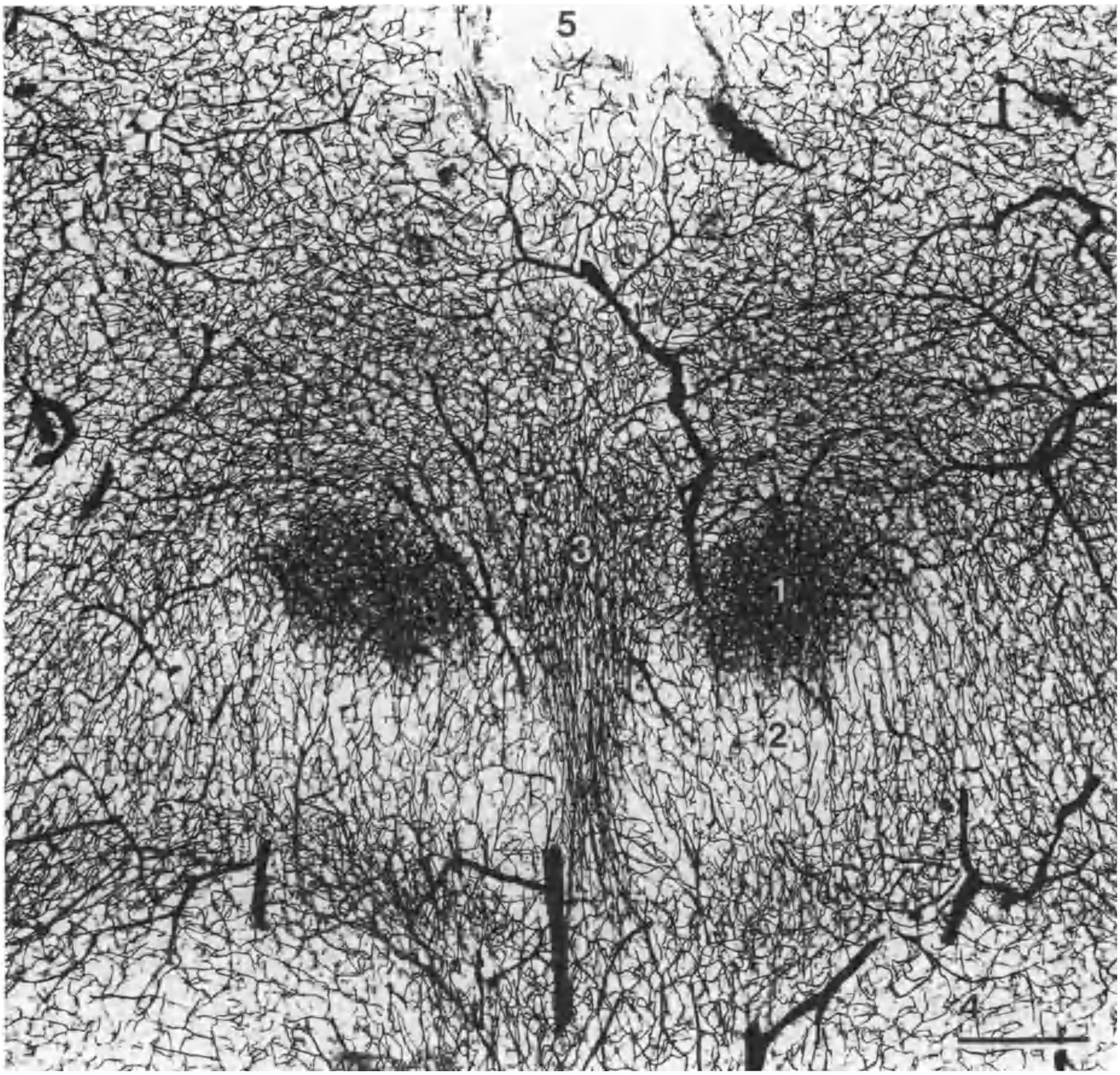
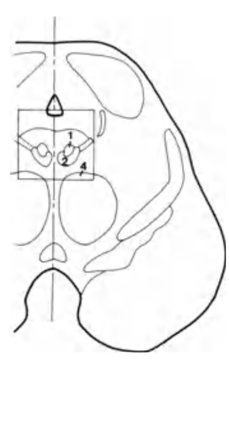


Fig. 152. Transverse Section of the Mesencephalon
Bar, 550 µm



1, Trochlear nucleus; **2**, medial longitudinal fasciculus; **3**, dorsal nucleus of the raphé; **4**, superior cerebellar peduncle; **5**, cerebral acqueduct

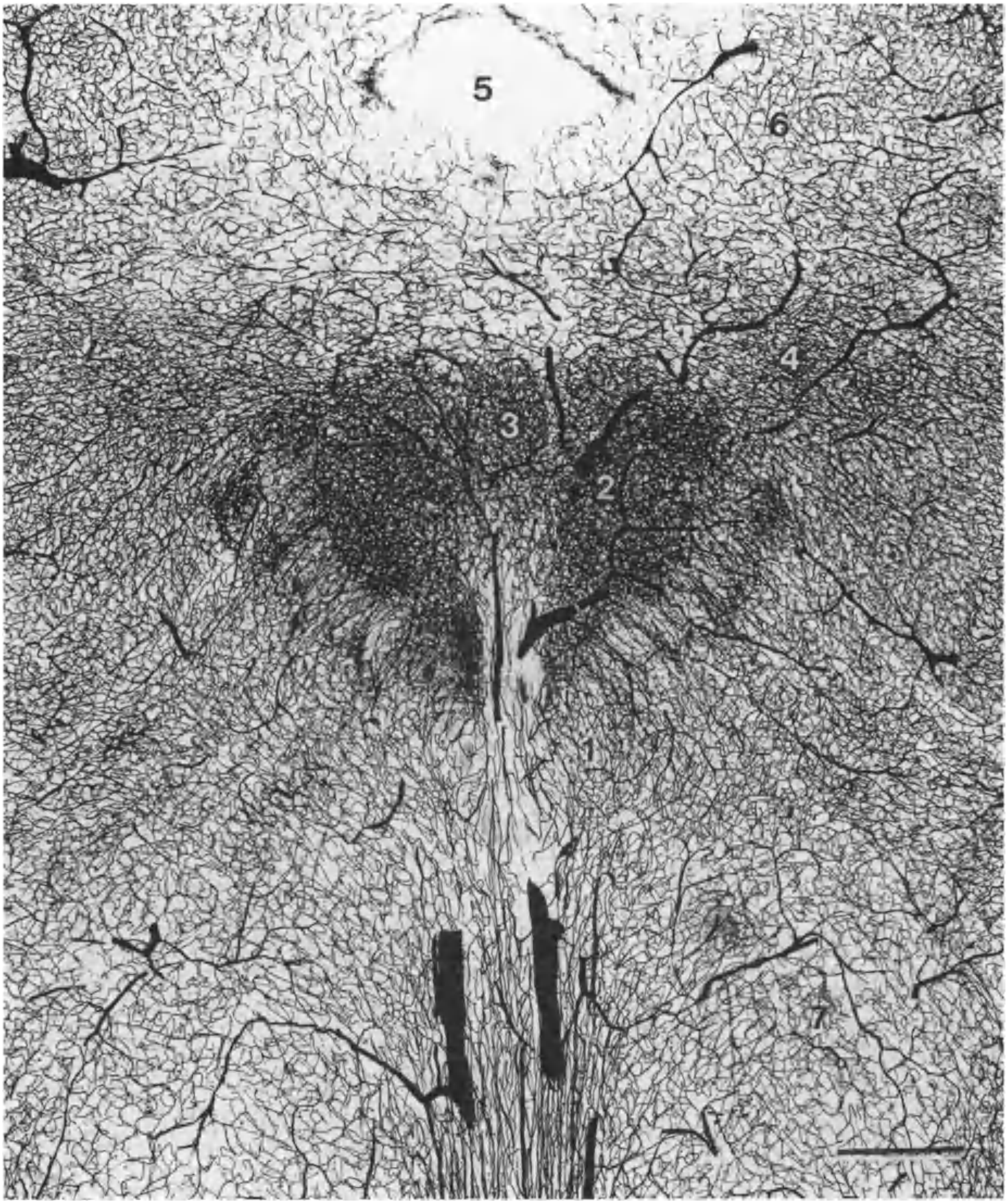
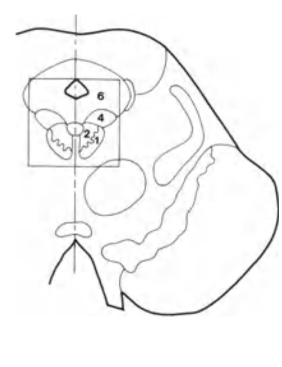


Fig. 153. Transverse Section of the Mesencephalon
Bar, 620 µm



1, Medial longitudinal fasciculus; **2**, main oculomotor nucleus; **3**, caudal central oculomotor nucleus; **4**, dorsal nucleus of the raphé; **5**, cerebral aqueduct; **6**, periacqueductal grey matter; **7**, superior cerebellar peduncle

Fig. 154. Transverse Section of the Mesencephalon
Bar, 900 µm

1, Medial longitudinal fasciculus; **2**, main oculomotor nucleus; **3**, central oculomotor nucleus (Perlia); **4**, accessory oculomotor nucleus (Edinger-Westphal); **5**, periaqueductal grey matter; **6**, cerebral aqueduct; **7**, red nucleus

Fig. 155. Transverse Section of the Mesencephalon
Bar, 1.3 mm

1, Medial longitudinal fasciculus; **2**, accessory oculomotor nucleus (Edinger-Westphal); **3**, interstitial nucleus (Cajal); **4**, nucleus of the posterior commissure (Darkschewitsch); **5**, periaqueductal grey matter; **6**, cerebral aqueduct; **7**, posterior commissure; **8**, pineal gland (see Fig. 175); **9**, superior colliculus; **10**, red nucleus

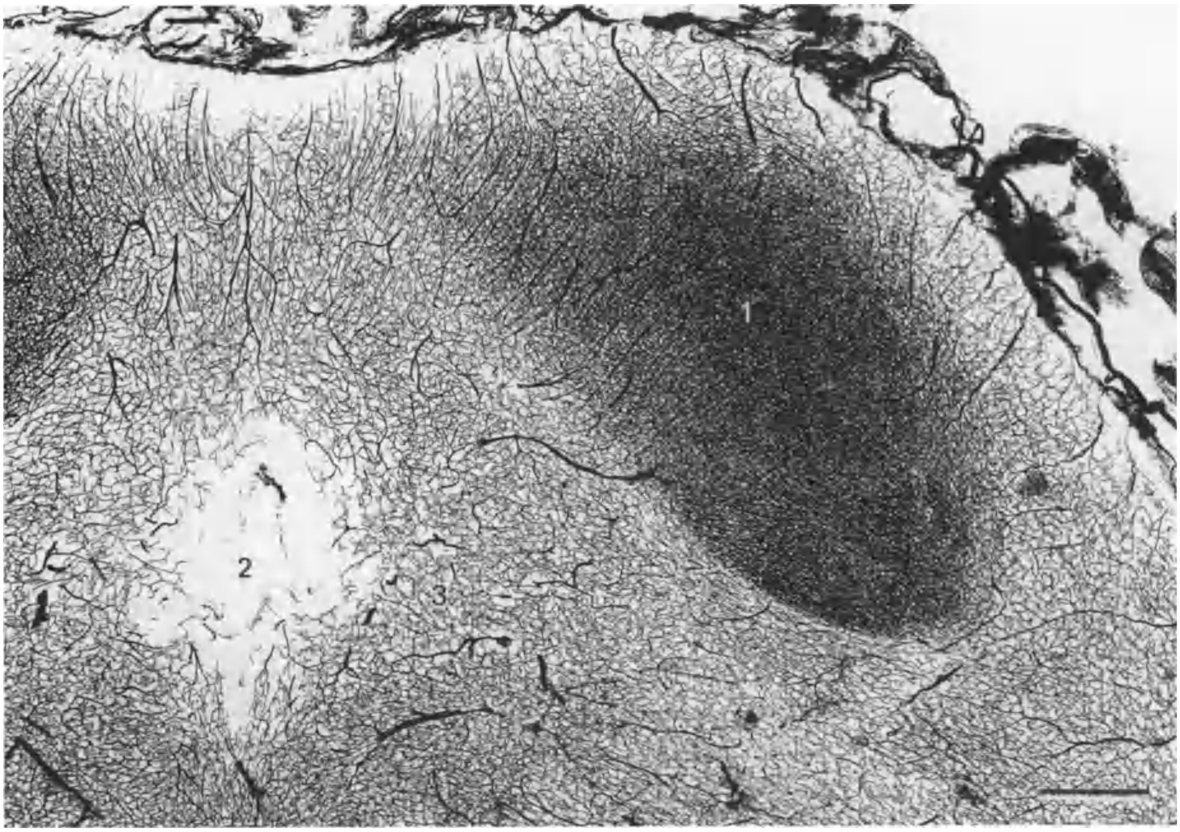
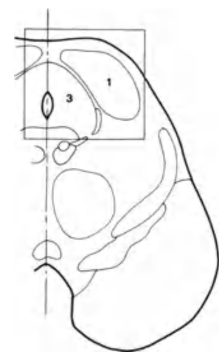


Fig. 156. Transverse Section of the Mesencephalon
Bar, 1 mm



1, Inferior colliculus; 2, cerebral aqueduct; 3, periaqueductal grey matter

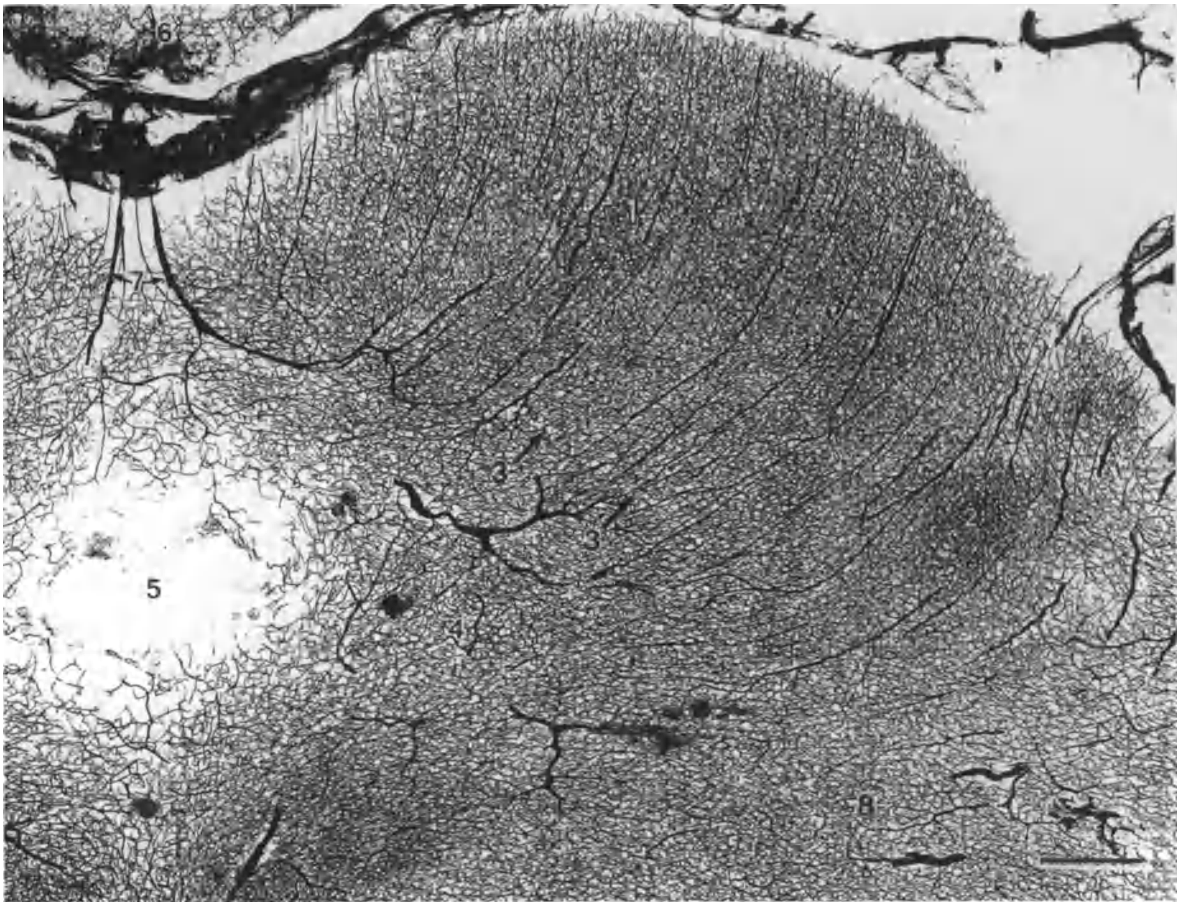


Fig. 157. Transverse Section of the Mesencephalon
Bar, 860 µm

1, Superior colliculus; **2**, nucleus intracuneiformis (see p. 148); **3**, mesencephalic trigeminal tract; **4**, periaqueductal grey matter; **5**, cerebral aqueduct; **6**, pineal gland; **7**, middle central collicular veins (see p. 55); **8**, nucleus reticularis cuneiformis

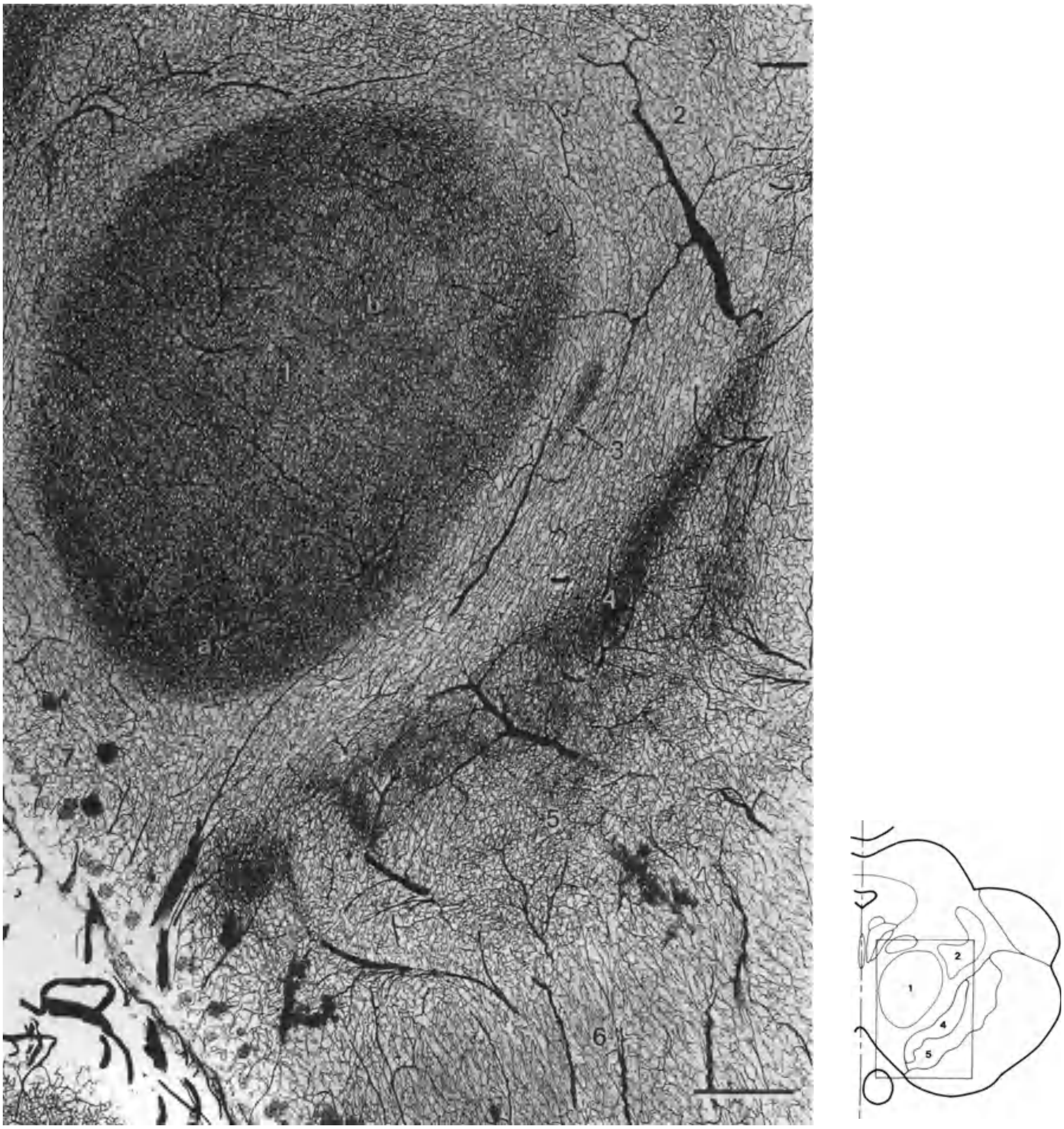


Fig. 158. Transverse Section of the Mesencephalon
Bar, 1.1 mm

1, Red nucleus; **a**, densely vascularized part; **b**, poorly vascularized part; **2**, medial lemniscus; **3**, nucleus intracapsularis; **4**, substantia nigra (pars compacta); **5**, substantia nigra (pars reticulata); **6**, crus cerebri; **7**, ventral tegmental area

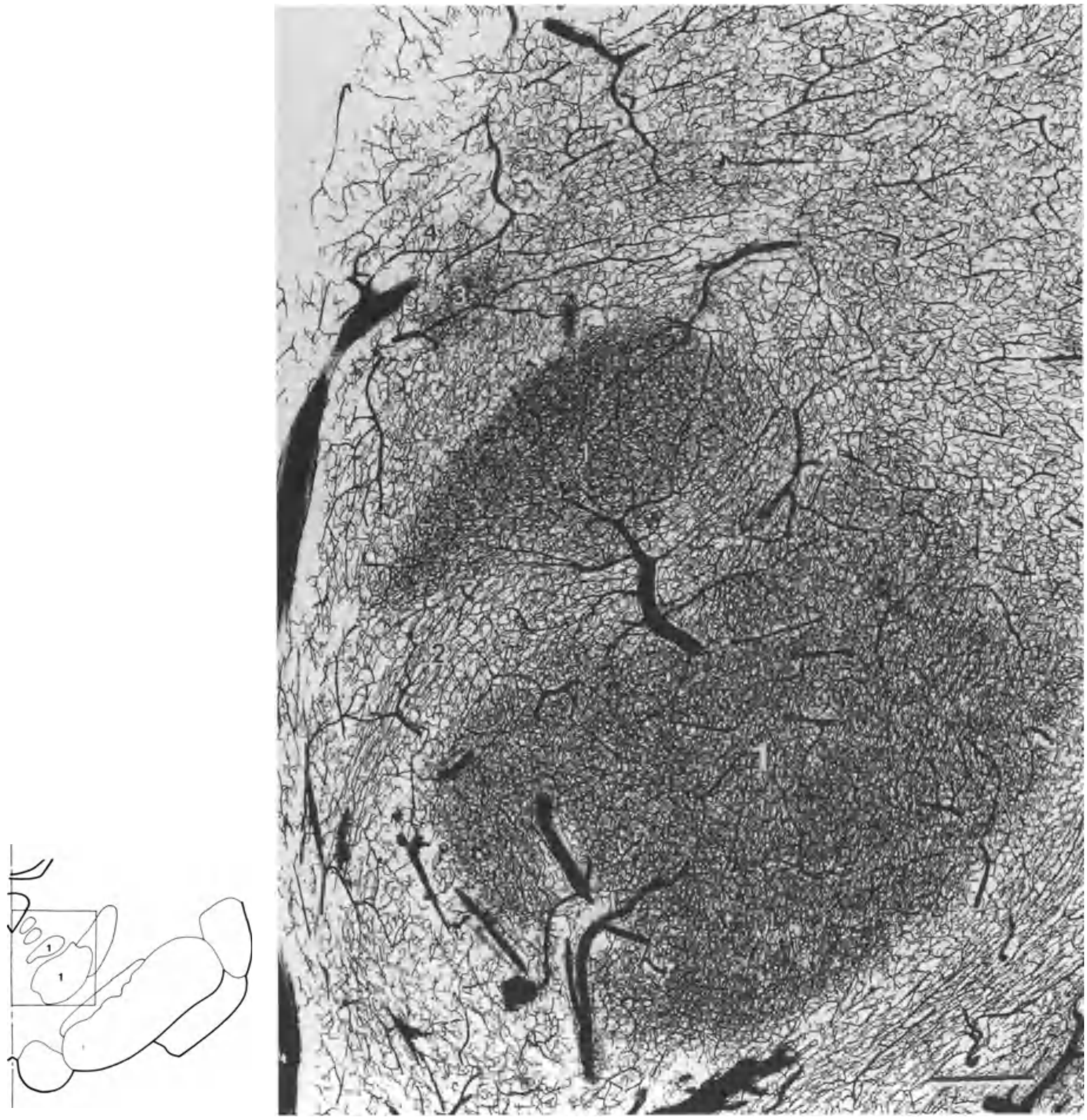
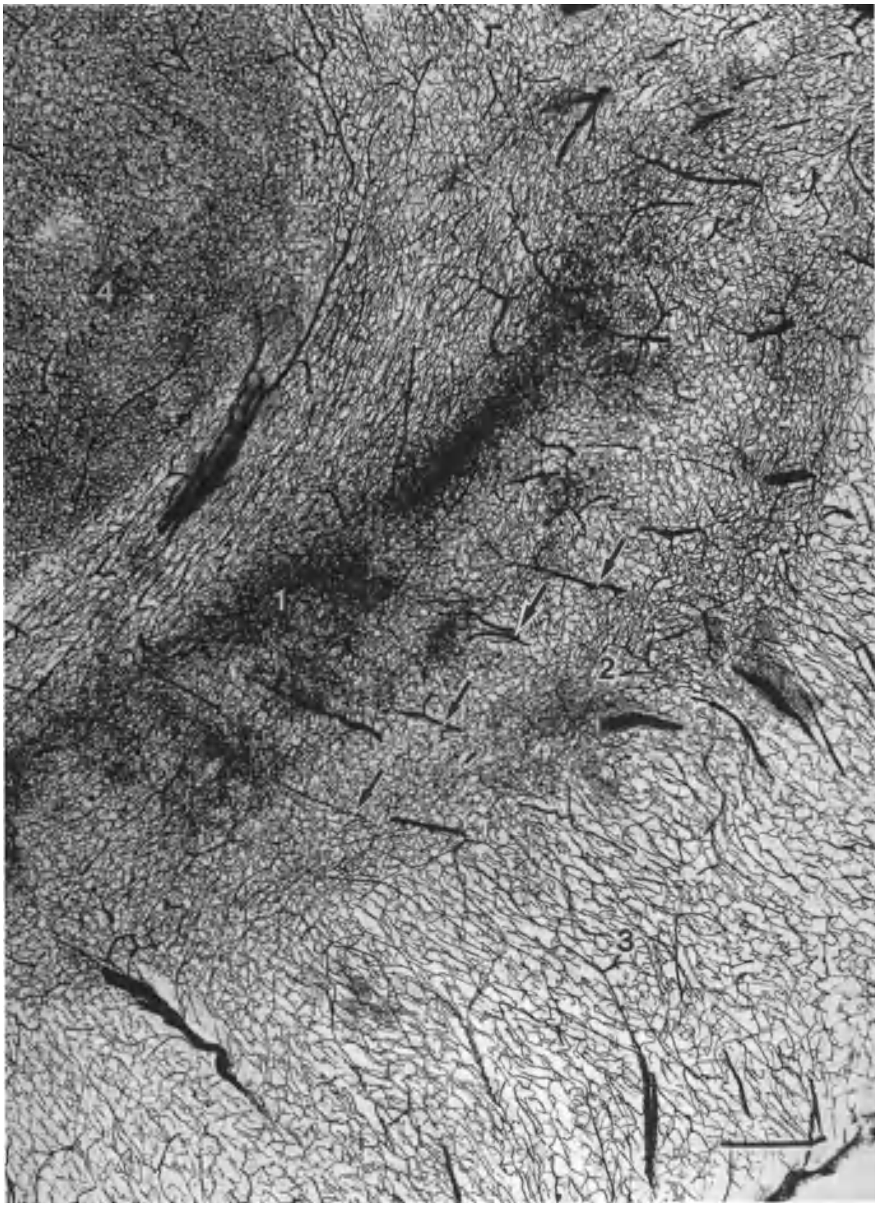


Fig. 159. Transverse Section of the Mesencephalon
Bar, 1 mm

1, Red nucleus; 2, habenulopeduncular tract; 3, interstitial nucleus (Cajal); 4, nucleus of the posterior commissure (Darkschewitsch)



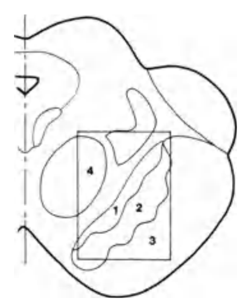


Fig. 160. Transverse Section of the Mesencephalon
Bar, 700 µm

1, Substantia nigra, pars compacta; **2**, substantia nigra, pars reticulata. The *arrows* show the arteries and veins belonging to the internal anterolateral group of mesencephalic vessels and reaching this section from a lower level (see Fig. 32).
3, Crus cerebri; **4**, red nucleus

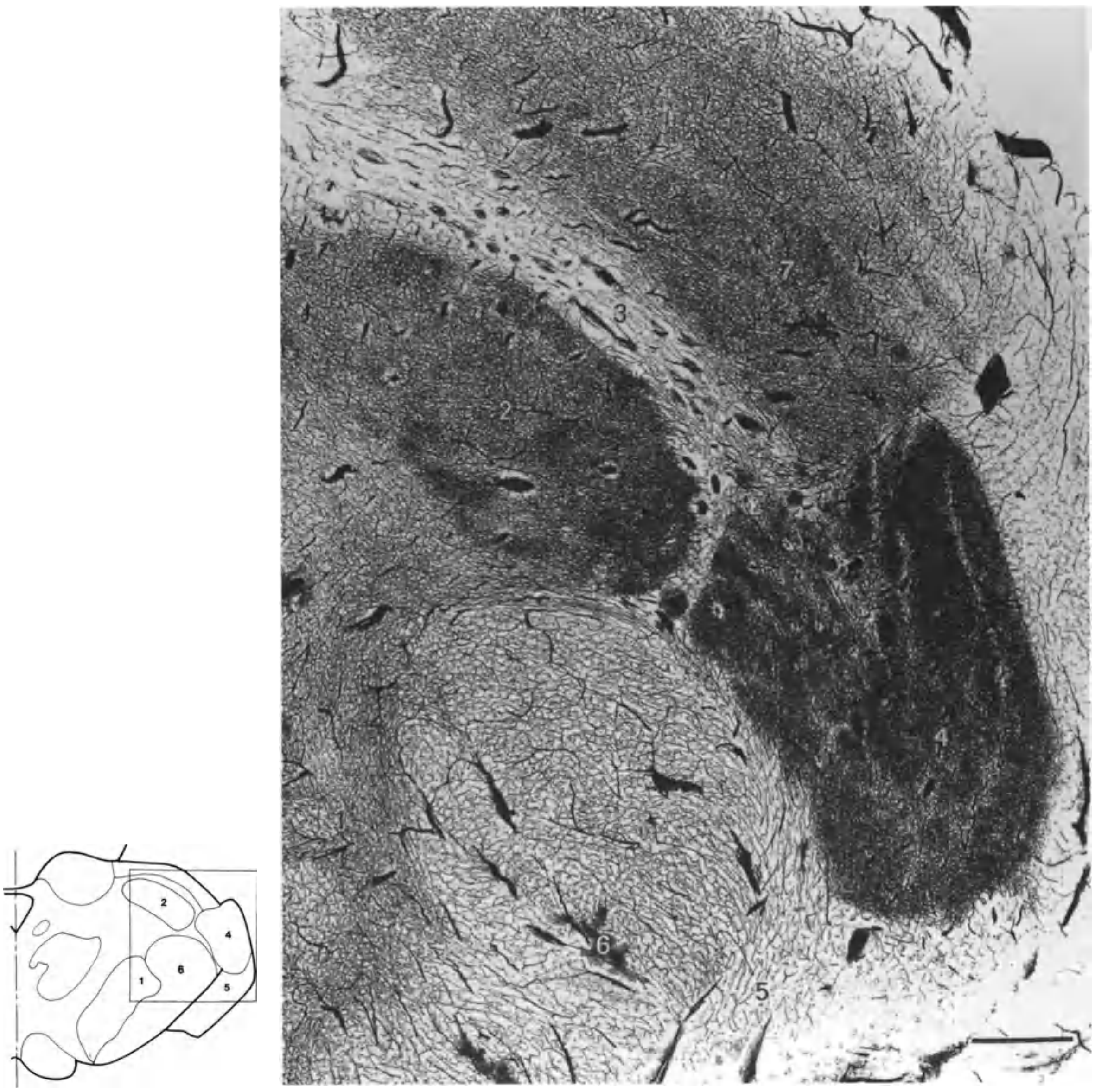
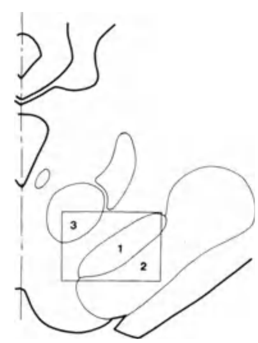


Fig. 161. Transverse Section of the Mesencephalon
Bar, 1.8 mm

1, Substantia nigra; **2**, medial geniculate body; **3**, superior collicular brachium; **4**, lateral geniculate body; **5**, optic tract; **6**, crus cerebri; **7**, pulvinar

Fig. 162. Transverse Section of the Mesencephalon
Bar, 1.2 mm



1, Subthalamic nucleus (note its characteristic oval shape);
2, crus cerebri; 3, red nucleus

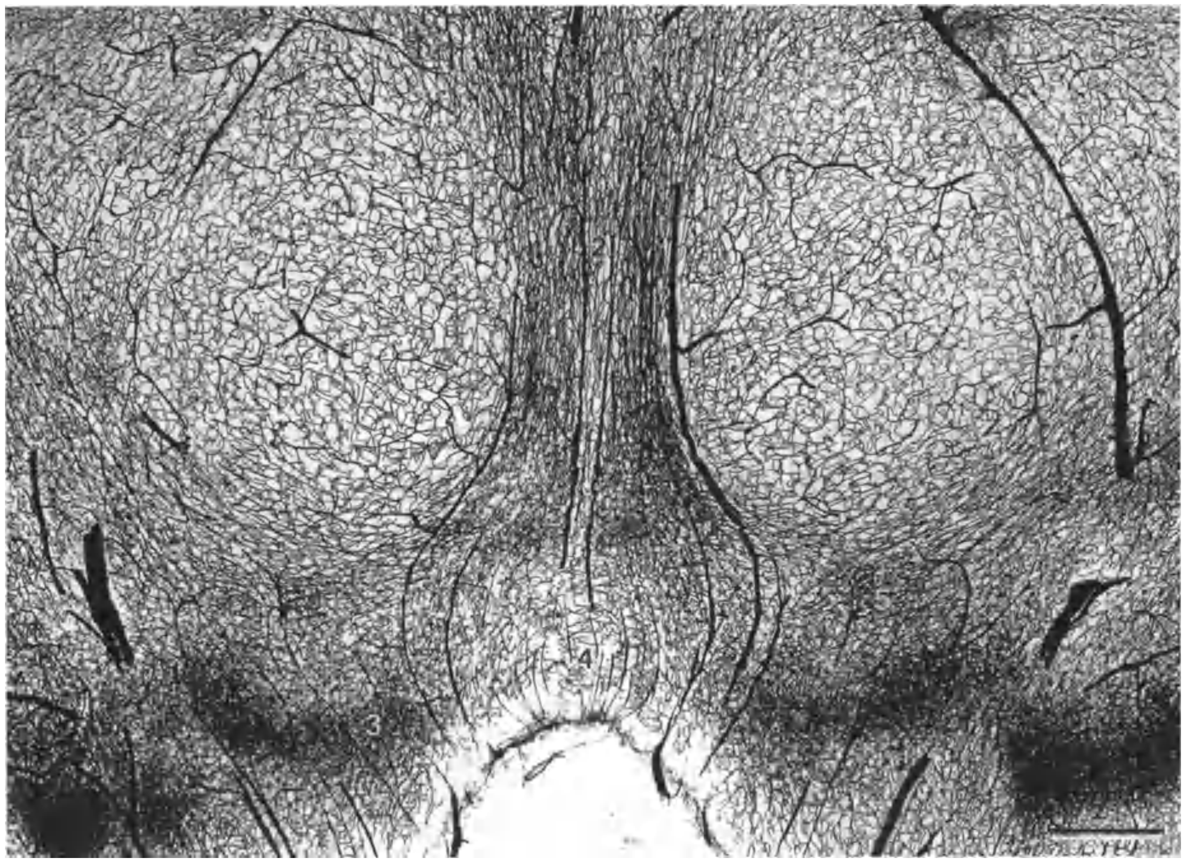
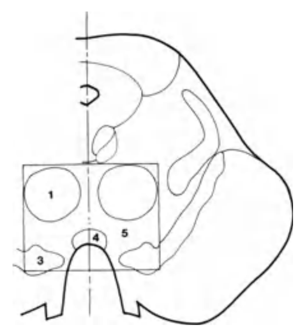
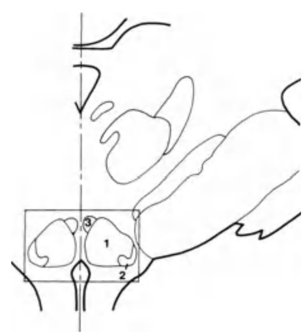


Fig. 163. Transverse Section of the Mesencephalon
Bar, 1.05 mm



1, Superior cerebellar peduncle (brachium conjunctivum);
2, dorsal nucleus of raphe; 3, substantia nigra pars compacta;
4, interpeduncular nucleus; 5, ventral tegmental area

Fig. 164. Transverse Section of the Mamillary Bodies
Bar, 800 μm



1, Mamillary body; **2**, fornix; **3**, mamillothalamic tract;
4, third ventricle; **5**, pars caudalis tuberis

Fig. 165. Coronal Section of the Mesencephalon (according to the brainstem axis). **Bar, 2.2 mm**

1, Inferior colliculus (note its dense vascular network); **2**, frenulum veli; **3**, superior colliculus; **4**, pineal gland; **4'**, pineal cystic cavity; **5**, habenular nucleus; **6**, third ventricle

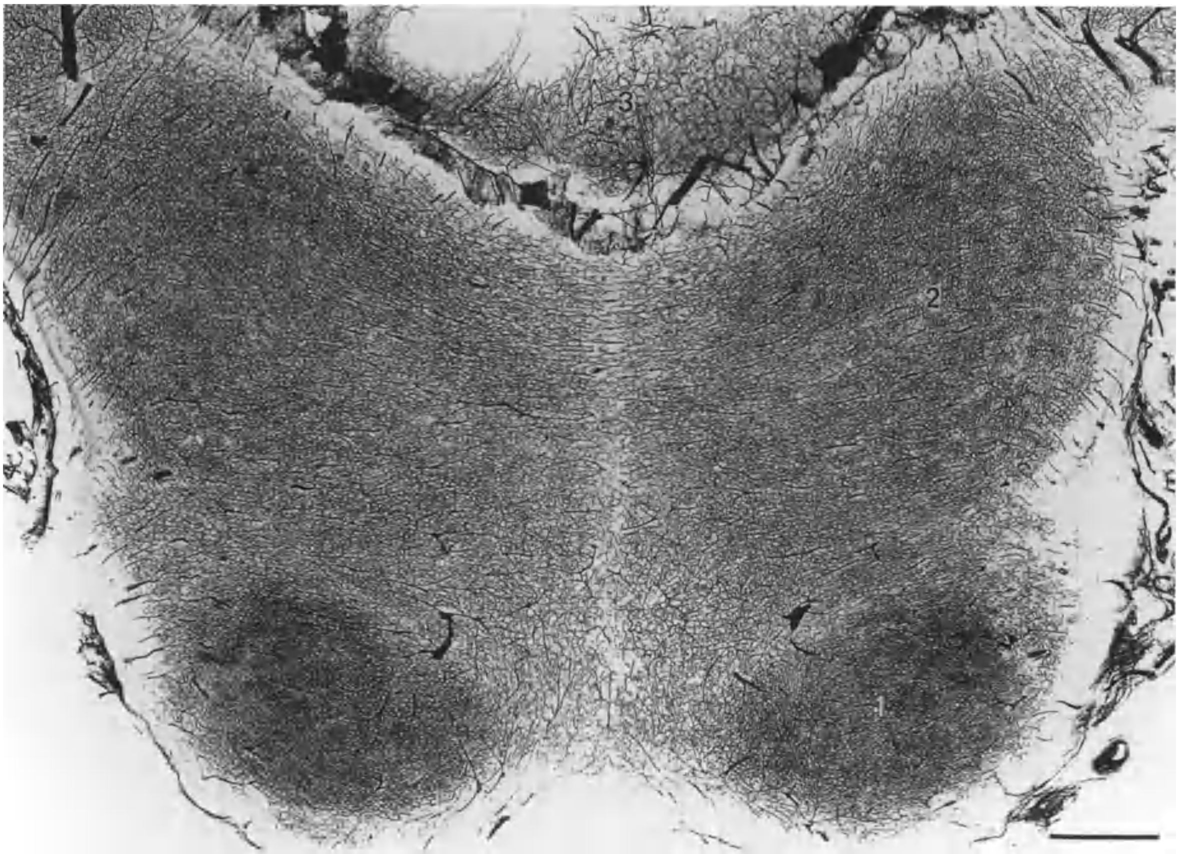


Fig. 166. Coronal Section of the Mesencephalon
Bar, 1.8 mm

1, Inferior colliculus (note its dense vascular network);
2, superior colliculus; **3**, pineal gland

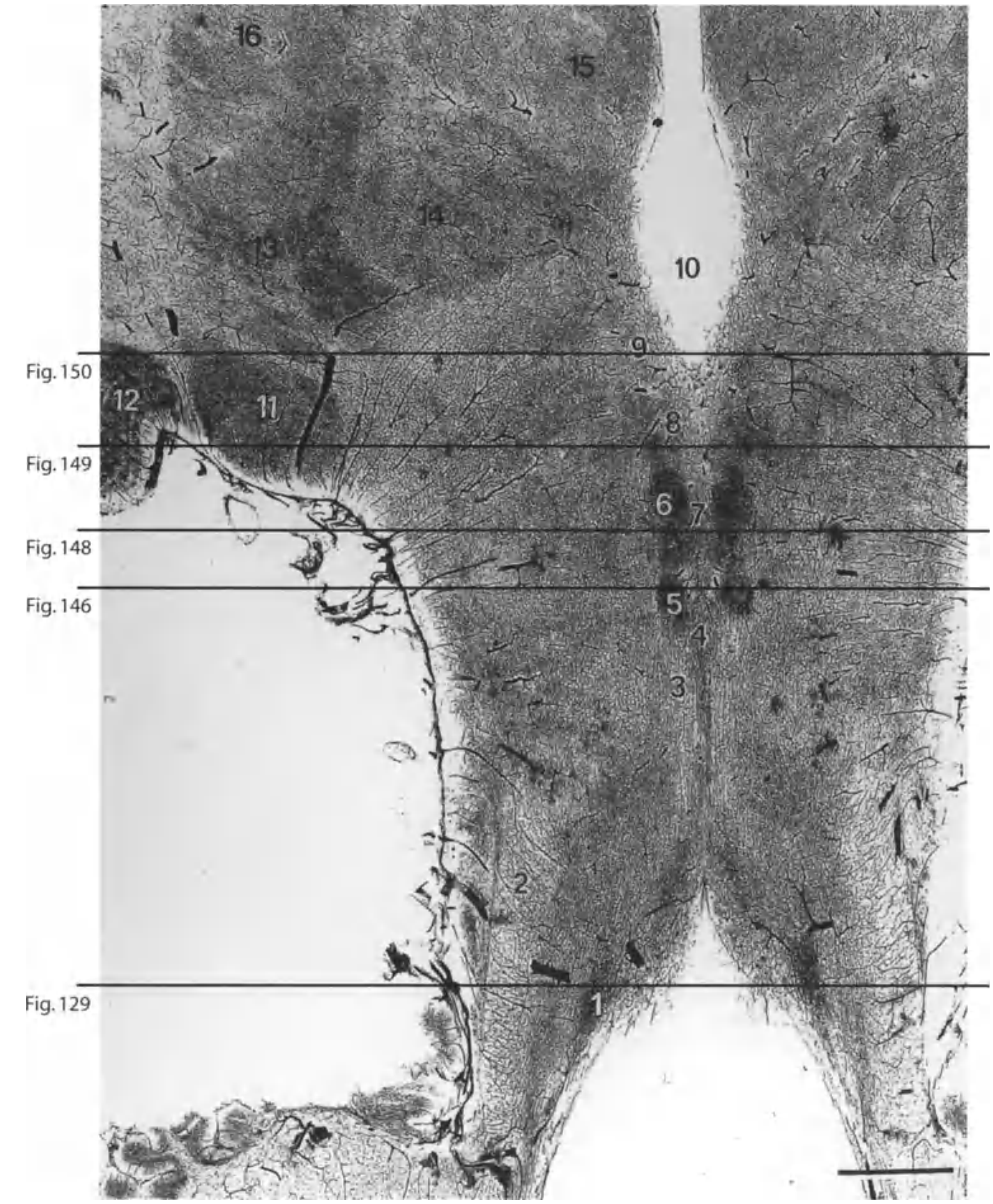


Fig. 167. Coronal Section of the Mesencephalon (according to the brainstem axis) (in the plane indicated in Figs. 129, 146, 148, 149, 150). **Bar, 2.5 mm**

1, Nucleus coeruleus; **2**, superior cerebellar peduncle (brachium conjunctivum); **3**, medial longitudinal fasciculus; **4**, dorsal nucleus of the raphé; **5**, trochlear nucleus; **6**, main oculomotor nucleus; **7**, caudal central oculomotor nucleus; **8**, accessory oculomotor nucleus (Edinger-Westphal); **9**, interstitial nucleus (Cajal); **10**, third ventricle; **11**, medial geniculate body; **12**, lateral geniculate body; **13**, ventral posterolateral thalamic nucleus; **14**, centromedian thalamic nucleus; **15**, mediodorsal thalamic nucleus; **16**, lateral posterior thalamic nucleus

Fig. 168. Coronal Section of the Mesencephalon
Bar, 1.2 mm

1, Medial longitudinal fasciculus; **2**, trochlear nucleus; **3**, dorsal nucleus of the raphé; **4**, main oculomotor nucleus; **5**, caudal central oculomotor nucleus; **6**, accessory oculomotor nucleus (Edinger-Westphal); **7**, interstitial nucleus (Cajal); **8**, Third ventricle

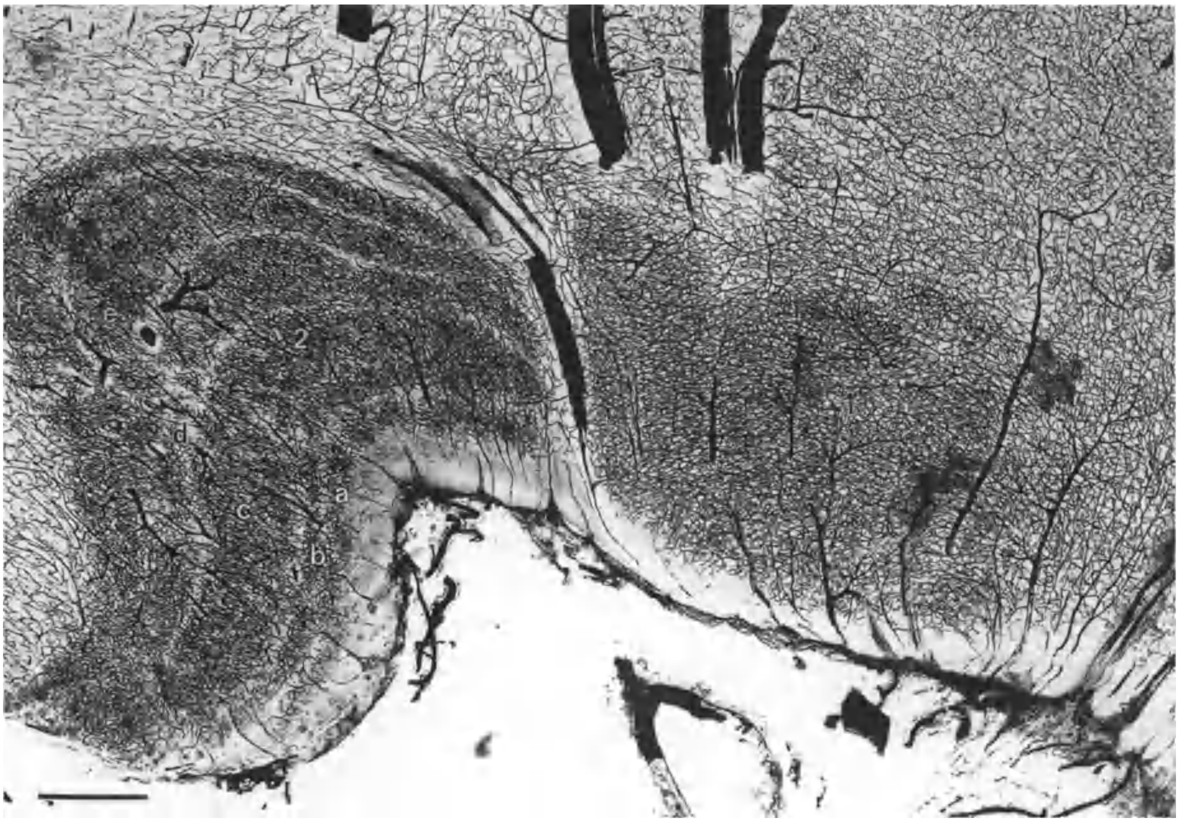


Fig. 169. Coronal Section of the Mesencephalon
Bar, 800 μm

1, Medial geniculate body; **2**, lateral geniculate body with its six layers (**a**, **b**, **c**, **d**, **e**, **f**); **3**, thalamogeniculate vessels

Figures 170–175 show the vascular network of the pineal gland in sections. For information about the superficial blood vessels of the pineal gland see Figs. 80–87.

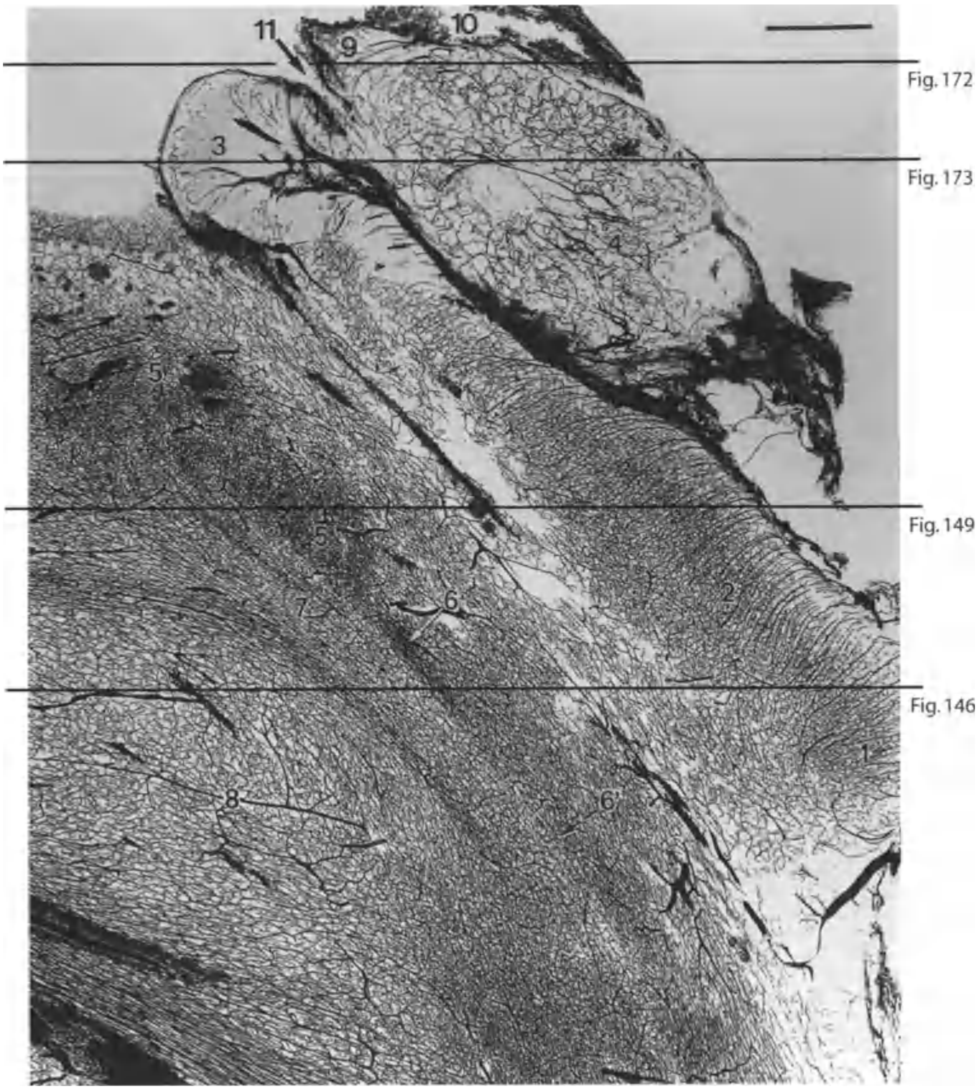


Fig. 170. Sagittal Section of the Pineal Gland and Mesencephalon (in the plane indicated in Figs. 146 and 149) (see correspondence with Figs. 172 and 173). **Bar, 2 mm**

1, Inferior colliculus; **2**, superior colliculus; **3**, posterior commissure; **4**, pineal gland; **5**, main oculomotor nucleus; **6**, trochlear nucleus; **6'**, accessory trochlear nucleus (see p. 148); **7**, medial longitudinal fasciculus; **8**, decussation of the superior cerebellar peduncle; **9**, habenular commissure; **10**, suprapineal recess; **11**, pineal recess

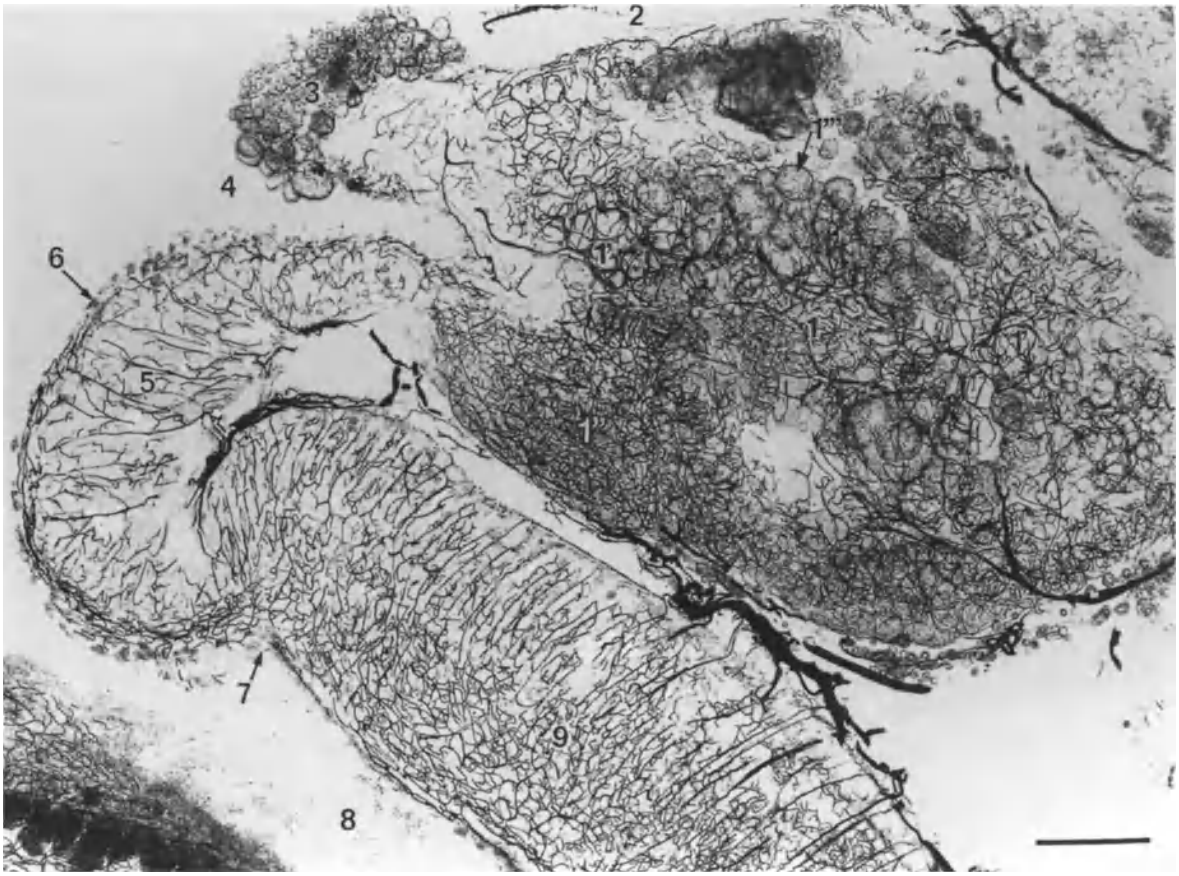


Fig. 171. Sagittal Section of the Pineal Gland. **Bar, 1.2 mm**

1, The *pineal gland*, whose pinealocytes elaborate the melatonin, belongs to the group of circumventricular organs characterized by the lack of blood brain barrier. (BARGMANN 1943; TAPP and HUXLEY 1972; TAPP 1979; REITER 1981; VOLLRATH 1984; MCKINLEY et al. 1990). Note the large vascular network with a mesh-like pattern surrounding the pineal lobules and concretions in the dorsal part of the pineal (1'), and the fine and dense vascular network in its ventral part (1"). These topographical features of the vascular pineal network were already described by FAZIO and PERRIA (1940). For more information about the vascular network of the pineal gland, see LE GROS CLARK (1940) and SELIM (1976). **1'''**, Pineal calcareous concretions (also called acervuli); **2**, suprapineal recess; **3**, habenular commissure; **4**, pineal recess; **5**, posterior commissure; **6**, subcommissural organ (the subcommissural organ belongs to the group of circumventricular organs; for more information see MCKINLEY and OLDFIELD 1990); **7**, mesocoelic recess (see RAKIC 1965; MCKINLEY and OLDFIELD 1990); **8**, cerebral acqueduct; **9**, periaqueductal grey matter

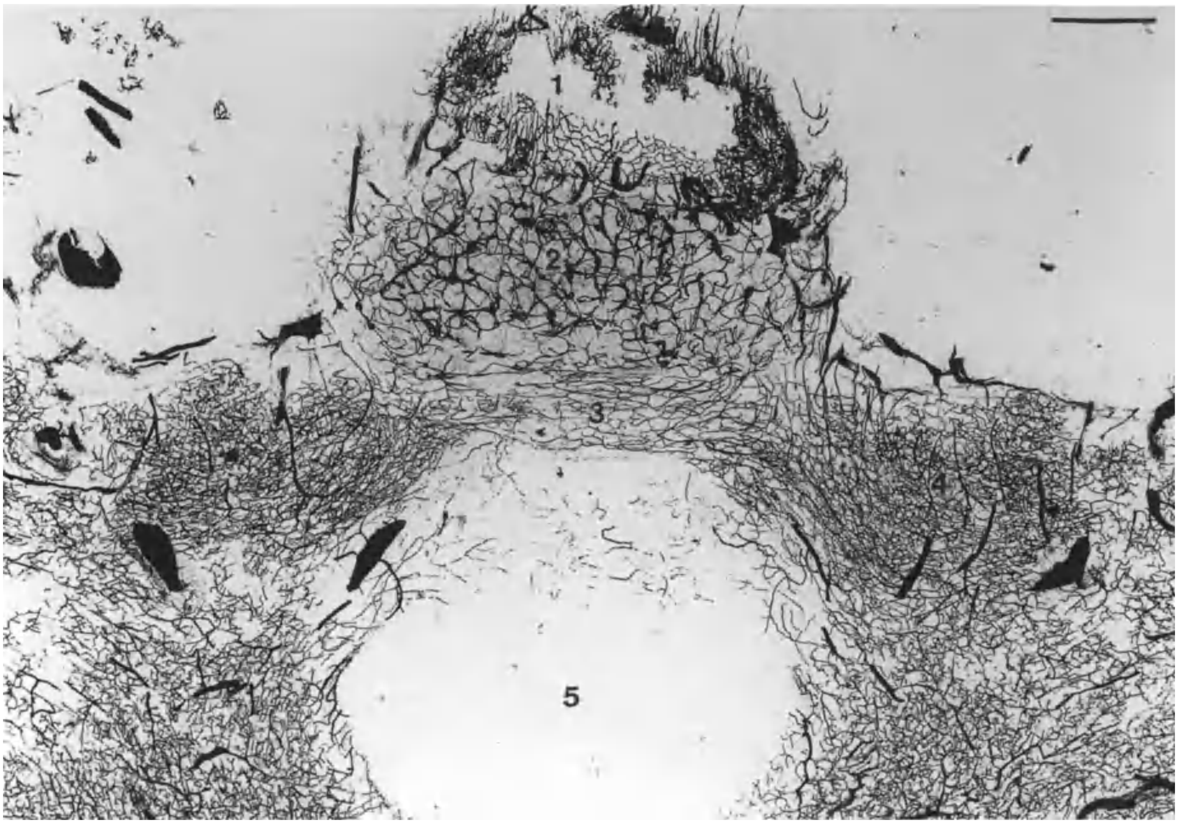
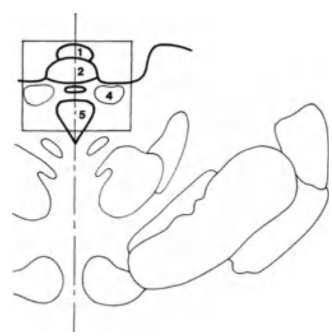


Fig. 172. Transverse Section of the Pineal Gland (see Fig. 170 for the plane of this section). **Bar, 1.4 mm**



1, Suprapineal recess; **2**, pineal gland. Note the large vascular network with a mesh-like pattern in the dorsal part of the pineal gland surrounding the pineal lobules. **3**, Habenular commissure; **4**, habenular nucleus; **5**, third ventricle

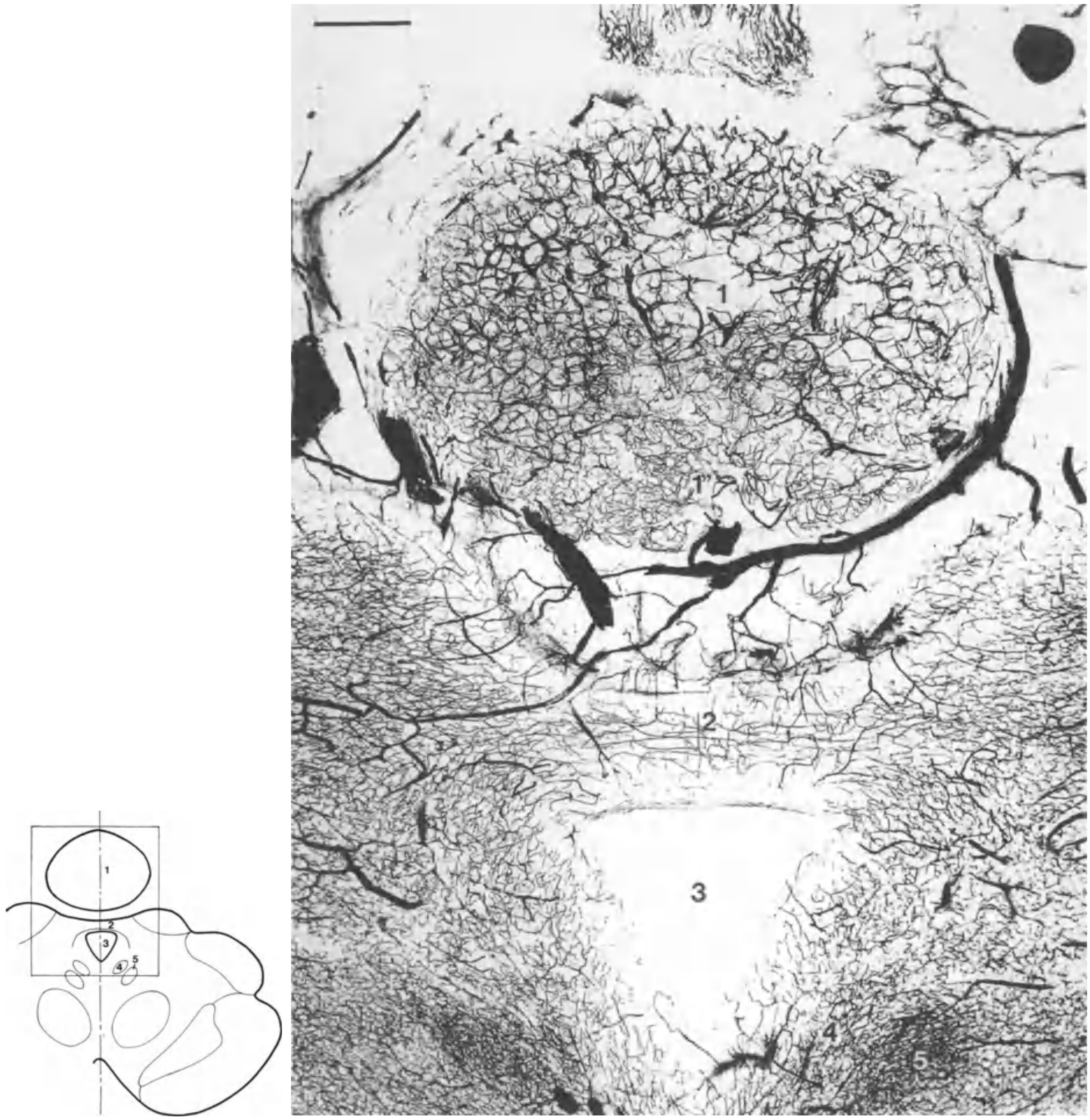


Fig. 173. Transverse Section of the Pineal Gland (see Fig. 170 for the plane of this section). **Bar, 1.4 mm**

1, Pineal gland. Note the large vascular network in the dorsal part of the gland (**1'**) and the fine and dense vascular network in its ventral part (**1"**). **2**, Posterior commissure; **3**, cerebral acqueduct; **4**, nucleus of the posterior commissure (Darkschewitsch); **5**, interstitial nucleus (Cajal)

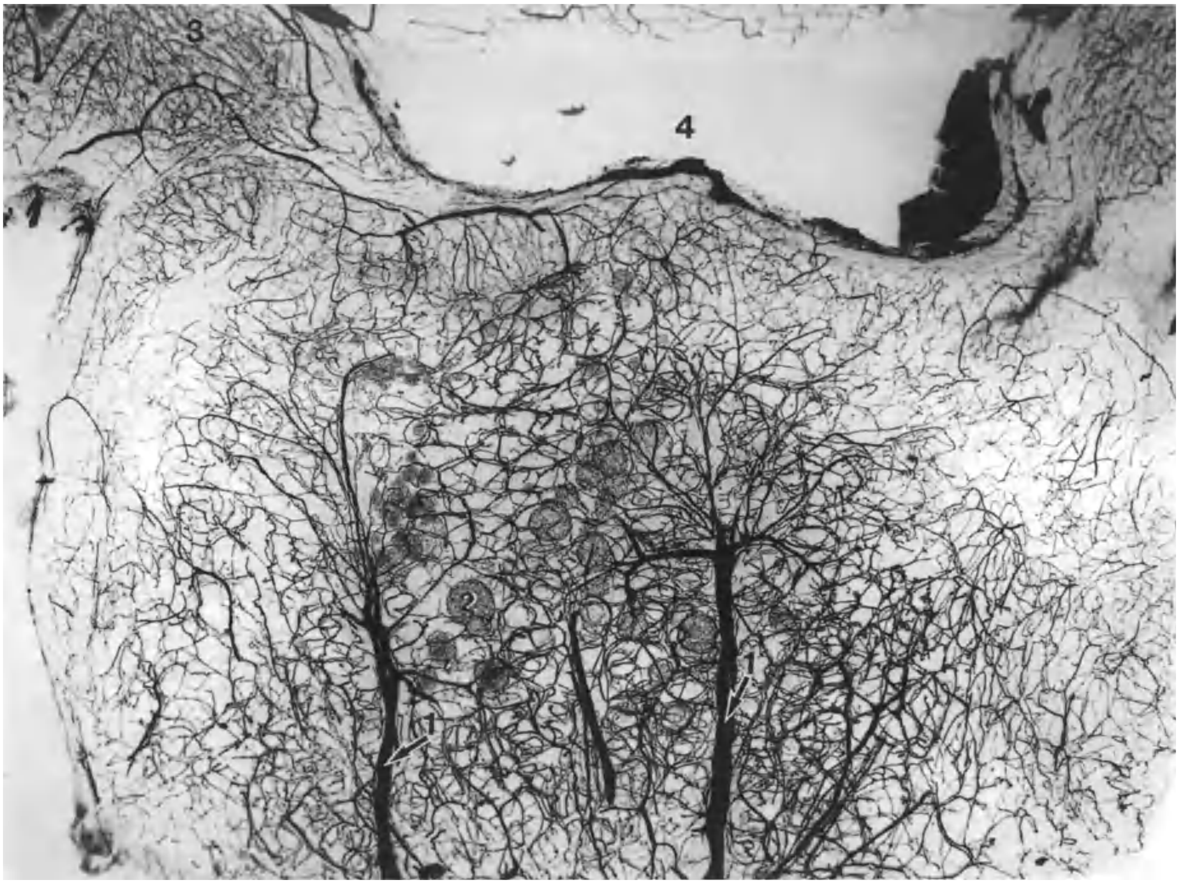


Fig. 174. Transverse Section of the Pineal Gland (according to its longitudinal axis). **Bar, 0.74 mm**

The vascular supply of the pineal gland depends on several internal longitudinal vascular axes cranially oriented (**1**). **2**, Pineal concretions; **3**, habenular nucleus; **4**, third ventricle

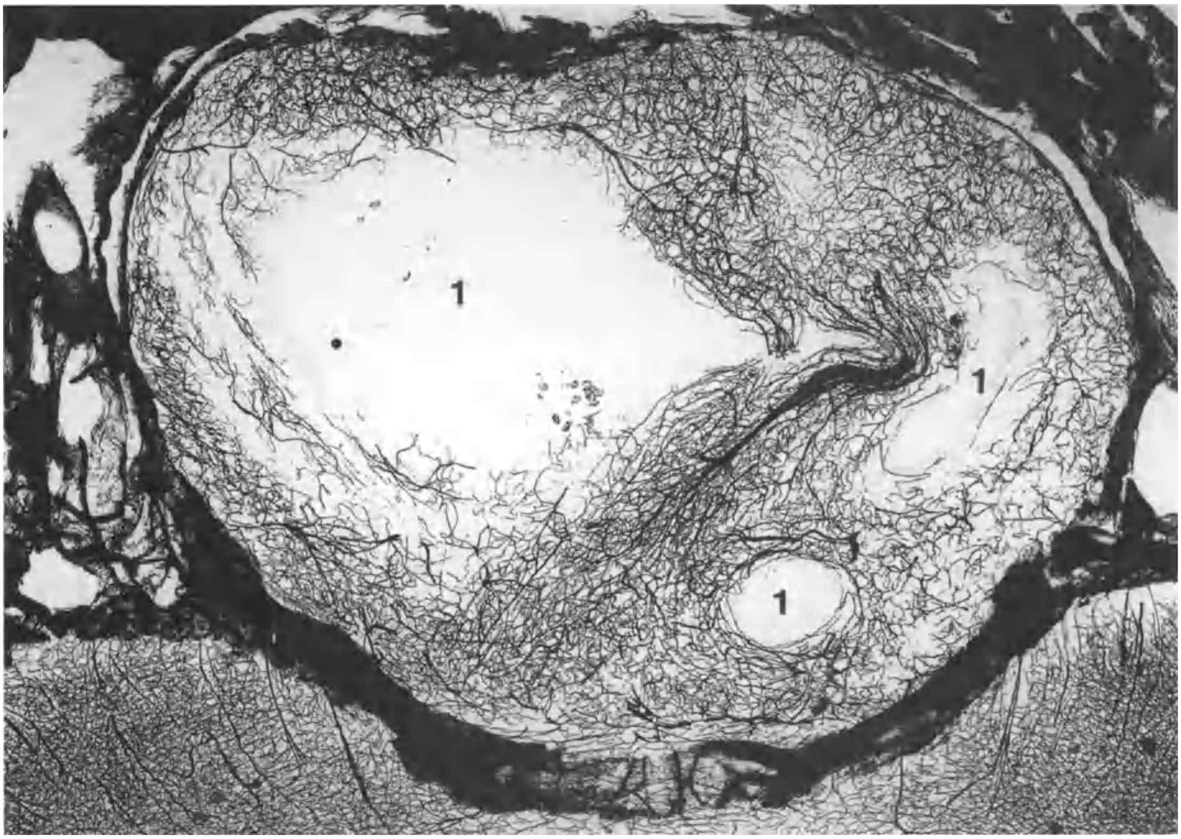


Fig. 175. Coronal Section of the Pineal Gland. **Bar, 1.1 mm**

The pineal vascular architecture is often drastically modified by the presence of vast cystic cavities (**1**) (see Fig. 86)

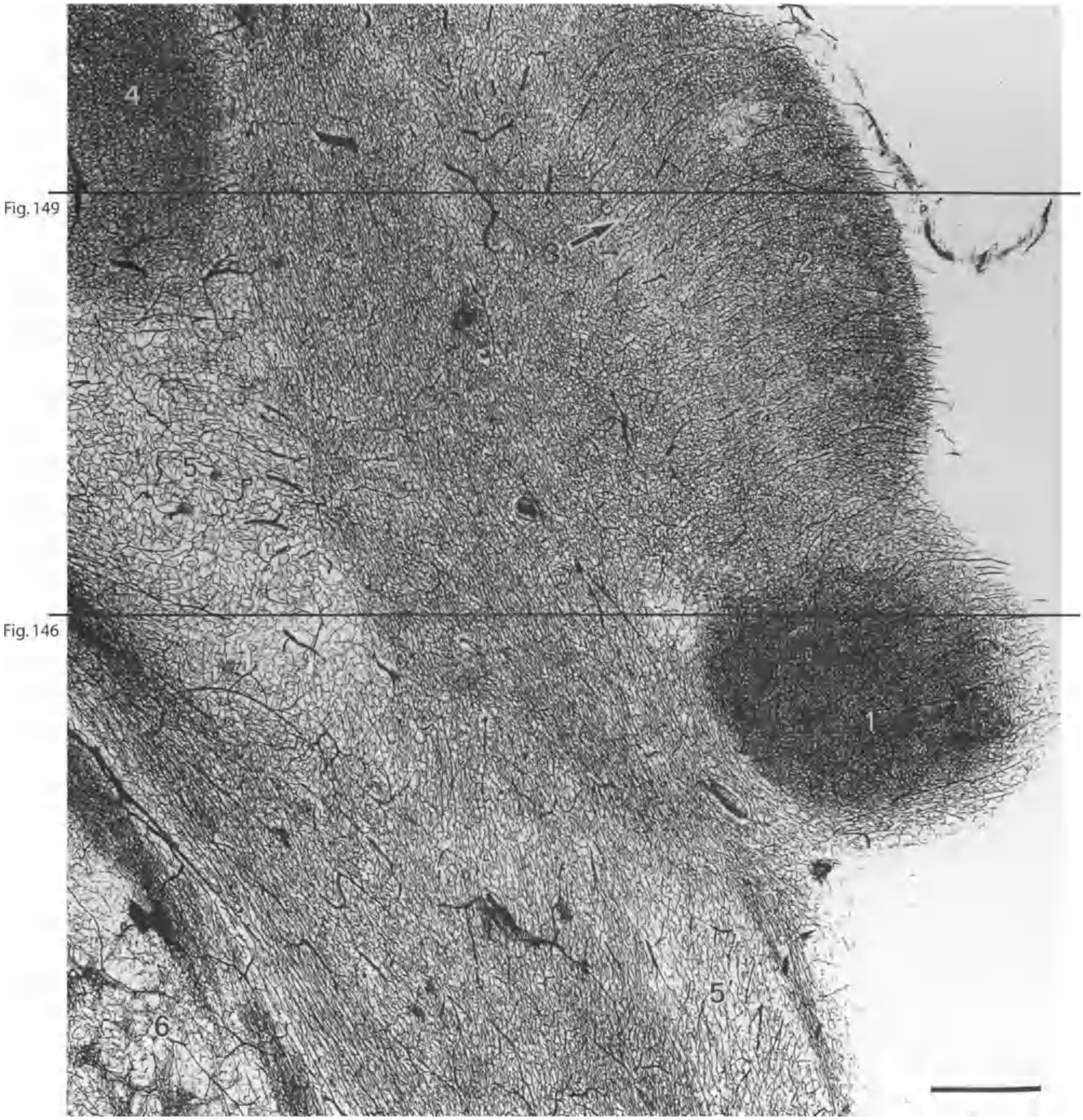


Fig. 176. Sagittal Section of the Mesencephalon (in the plane indicated in Figs. 146 and 149). **Bar, 1.4 mm**

1, Inferior colliculus (note its dense vascular network); **2**, superior colliculus; **3**, mesencephalic trigeminal tract; **4**, red nucleus; **5** and **5'**, superior cerebellar peduncle (brachium conjunctivum); **6**, ventral part of the pons

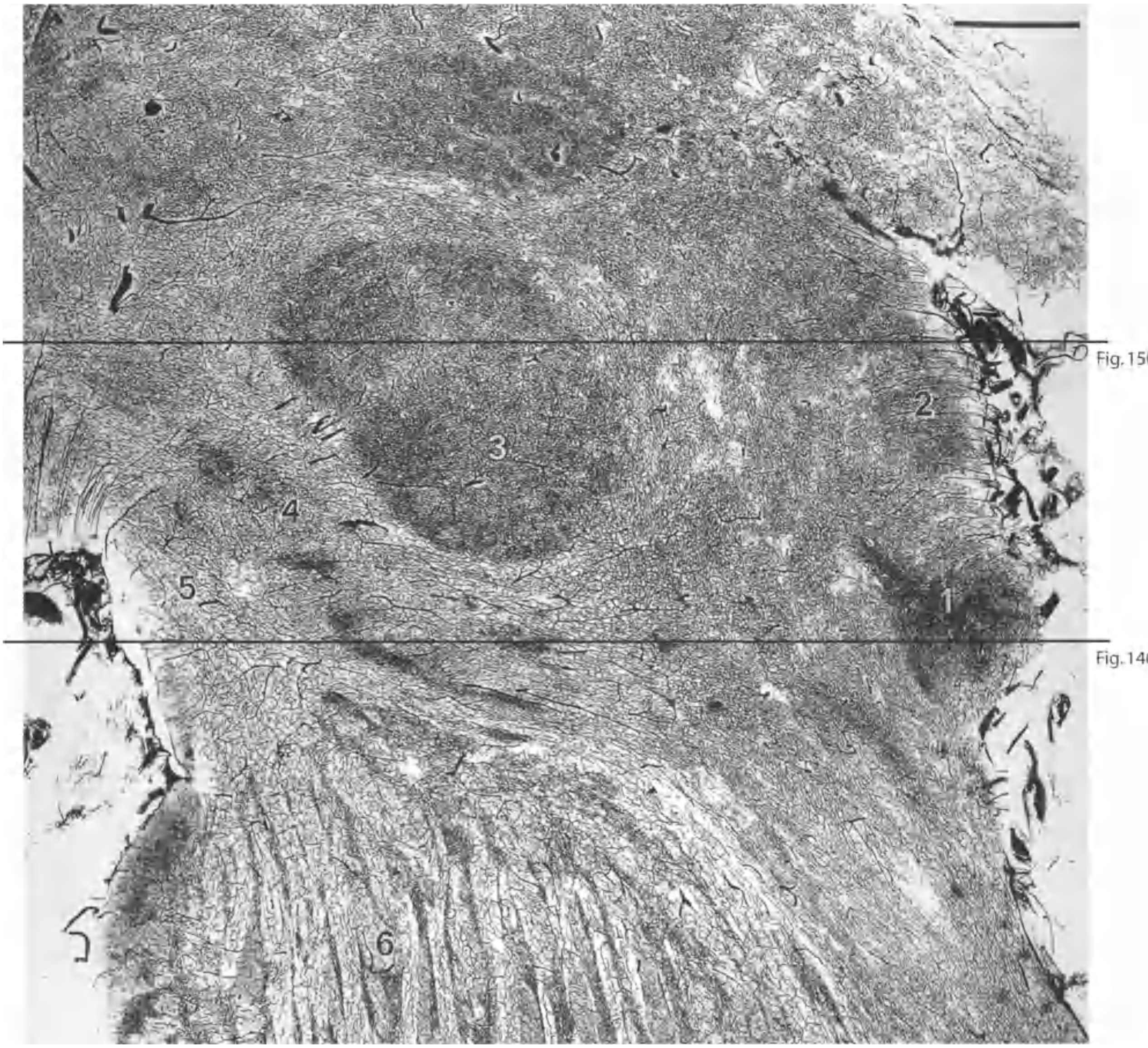


Fig. 177. Sagittal Section of the Mesencephalon (in the plane indicated in Figs. 146 and 150). **Bar, 3.3 mm**

1, Inferior colliculus; **2**, superior colliculus; **3**, red nucleus; **4**, substantia nigra; **5**, crus cerebri; **6**, ventral part of the pons

PART III

An Introduction to the Localization of Brain Stem Infarction

One of the aims of this book was to help to localise the infarction in the brain stem thanks to the preceding description of the arterial territories.

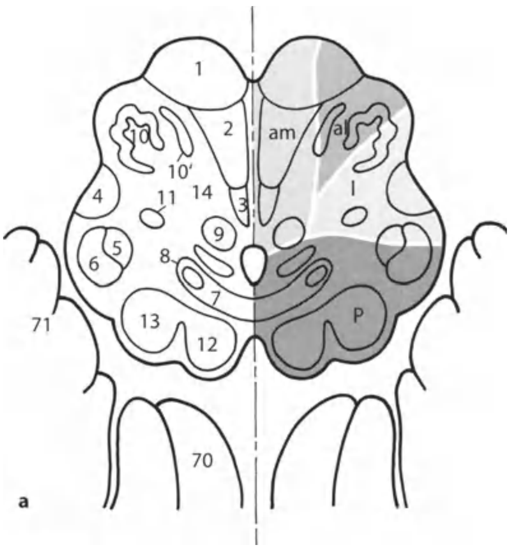
Thus, Figs. 178–187 show ten axial sections corresponding to the sections described in Figs. 24–33. These ten sections are oriented in relation to the usual MRI views and to the bicommissural plane. On the right side of each section, the structures are labelled (for more details see DUVERNOY 1995) and on the left side, the arterial territories are delineated according to the description found in Figs. 24–33 (see also DUVERNOY 1995 and TATU et al. 1996). Of course, the extension of the arterial territories (*am*, anteromedial; *al*, anterolateral; *l*, lateral; and *p*, posterior) may be subject to variations. MRI views showing ischaemic lesions are compared to these arterial territories.

An abundant literature exists concerning the arterial territories in the brain stem and their correlation to ischaemic lesions (see in particular, GILLILAN, (1964); SAVOIARDO et al., (1987); HELGASON and WILBUR, (1991); SACCO et al., (1993); BOGOUSSLAVSKY et al., (1994); VUILLEMIER et al., (1995); BASSETTI et al., (1996); TOYODA et al., (1996); GRAND et al., (1997); KATAOKA et al., (1997); KIM et al., (1998). On the other hand, the venous territories (seen in Figs. 24–33) are very rarely taken into account.

In MRI views, the infarcts are most frequently found in the anteromedial, anterolateral and lateral arterial territories of the brain stem. Lesions in the posterior territories of medulla and pons are often associated with cerebellar lesions. In the mesencephalon, infarcts in the anteromedial territory are often associated with thalamic infarction. Finally, the posterior mesencephalic territory is rarely the location of infarcts. This may be due to the dense anastomotic arterial network supplying the mesencephalic tectum (see Figs. 21 and 88–93).

Key to Structures

1	corticospinal tract
2	medial lemniscus
3	medial longitudinal fasciculus
4	spinothalamic tract
5	spinal trigeminal nucleus
6	spinal trigeminal tract
7	nucleus of the solitary tract
8	dorsal motor vagal nucleus
9	hypoglossal nucleus
10	inferior olivary nucleus
10′	medial accessory olivary nucleus
10″	dorsal accessory olivary nucleus
11	nucleus ambiguus
12	gracile nucleus
13	cuneate nucleus
13′	accessory cuneate nucleus
14	nucleus reticularis medullae oblongatae centralis
15	inferior cerebellar peduncle
16	area postrema
17	medial vestibular nucleus
18	inferior vestibular nucleus
19	lateral vestibular nucleus
20	superior vestibular nucleus
21	dorsal cochlear nucleus
22	ventral cochlear nucleus
23	facial nucleus
24	nucleus gigantocellularis
25	nucleus praepositus
26	nucleus raphes magnus
27	pontine nuclei
28	pontocerebellar fibers
29	middle cerebellar peduncle
30	superior olivary nucleus
31	abducent nucleus
32	lateral lemniscus
33	nucleus reticularis pontis caudalis
34	nucleus reticularis pontis oralis
35	motor trigeminal nucleus
36	principal sensory trigeminal nucleus
37	mesencephalic trigeminal nucleus and tract
38	superior cerebellar peduncle
39	nucleus coeruleus
40	parabrachial nuclei
41	frontopontine tract
42	parietotemporopontine tract
43	substantia nigra pars compacta
44	substantia nigra pars reticulata
45	ventral tegmental area
46	trochlear nucleus
47	periacqueductal gray
48	dorsal nucleus of raphé
49	nucleus reticularis cuneiformis
50	nucleus reticularis pedunculopontinus
51	nucleus ruber
52	main (principal) oculomotor nucleus
53	accessory oculomotor nucleus
54	inferior colliculus
55	superior colliculus
56	medial geniculate body
57	lateral geniculate body
58	optic tract
59	mamillary body
60	hypoglossal nerve
61	vagus nerve
62	vestibulocochlear nerve
63	facial nerve
64	pontomedullary sulcus
65	abducent nerve
66	trigeminal nerve (sensory root)
67	trigeminal nerve (motor root)
68	trochlear nerve
69	oculomotor nerve
70	tonsil
71	biventer lobule
72	uvula
73	flocculus
74	nodulus
75	quadrangular lobule
76	central lobule
77	ala of central lobule
78	culmen
79	dentate nucleus



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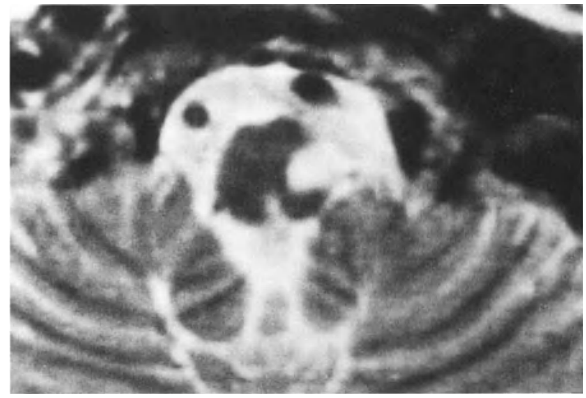
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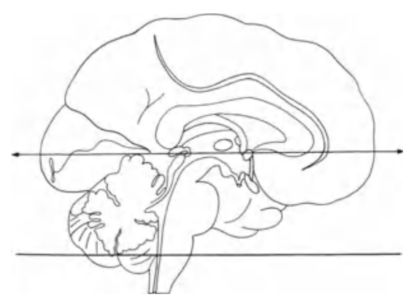


Fig. 178a. Transverse Section of the Medulla (inferior level). For more information, see Fig. 24. *am*, anteromedial medullary territory; *al*, anterolateral medullary territory; *l*, lateral medullary territory; *p*, posterior medullary territory
b Infarct involving the lateral (*l*) medullary territory
c Infarct involving the anterolateral (*al*) and lateral (*l*) medullary territories

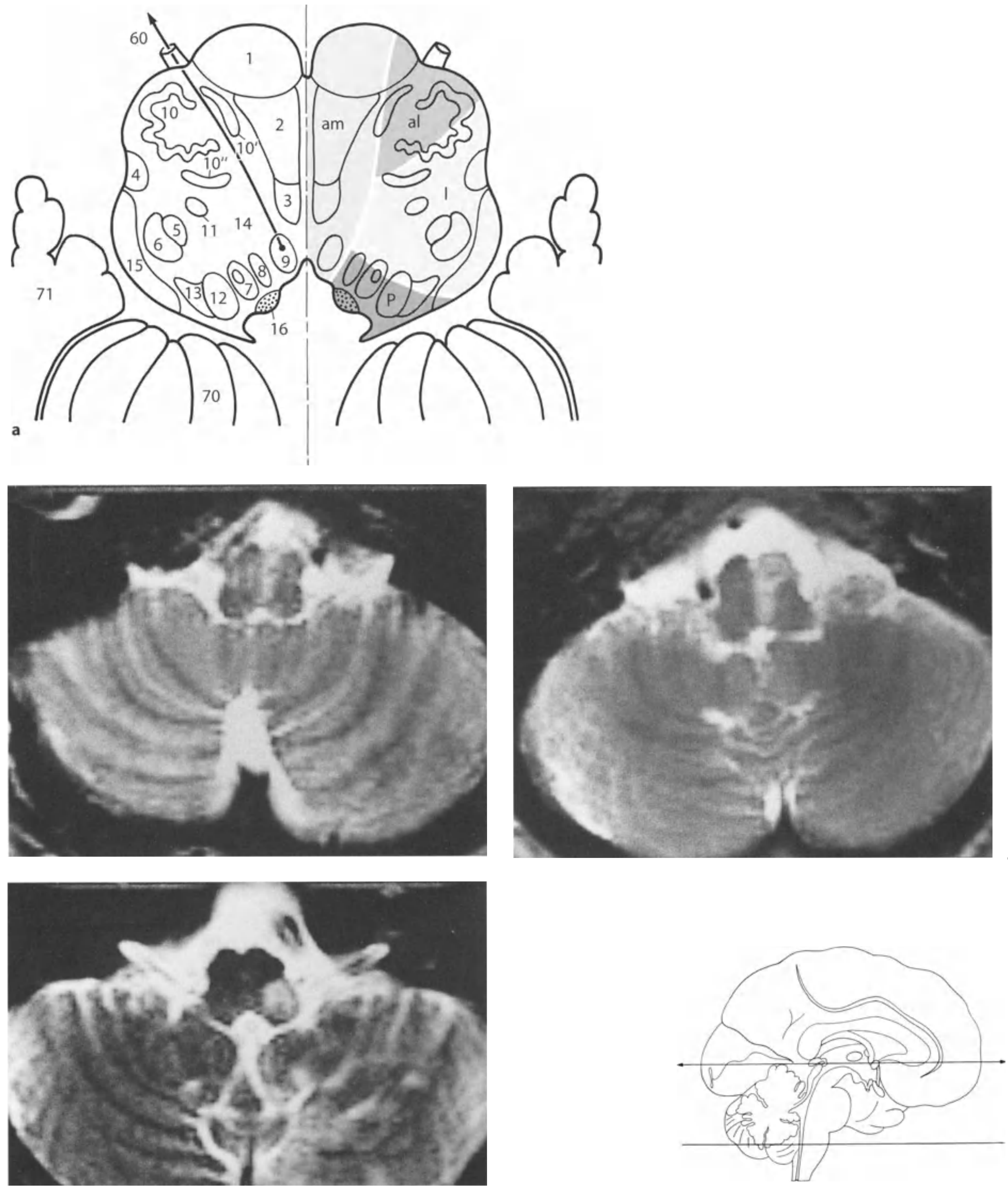
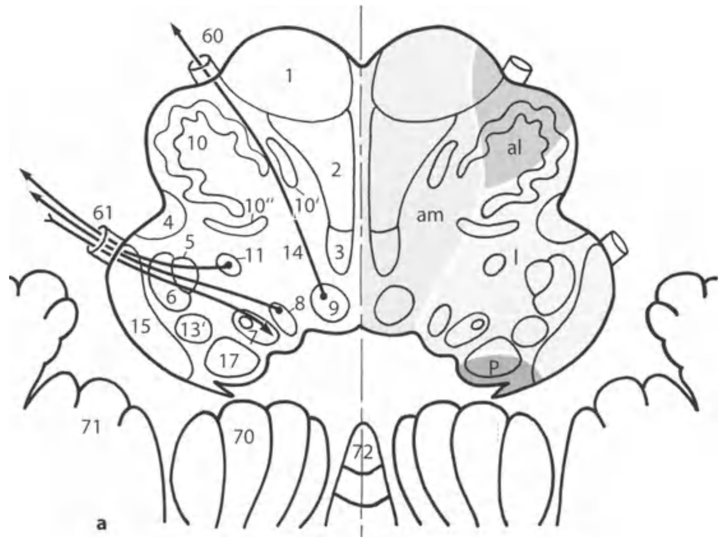


Fig. 179a. Transverse Section of the Medulla (inferior level). For more information, see Fig. 25. *am*, anteromedial medullary territory; *al*, anterolateral medullary territory; *l*, lateral medullary territory; *p*, posterior medullary territory
b Infarct involving the anteromedial (*am*) medullary territory
c Infarct involving the anteromedial (*am*) and anterolateral (*al*) medullary territories
d Infarct involving the lateral (*l*) medullary territory



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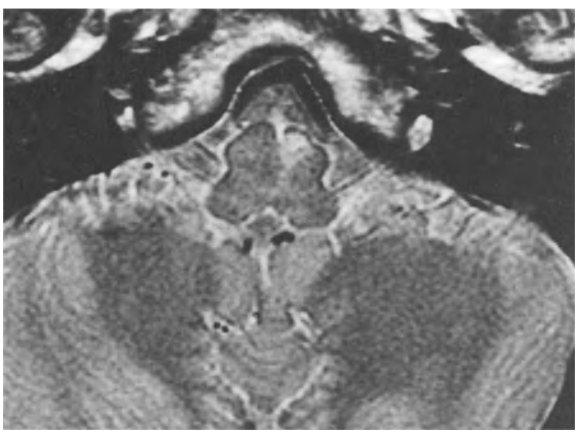

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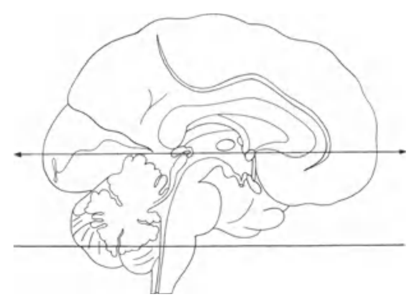
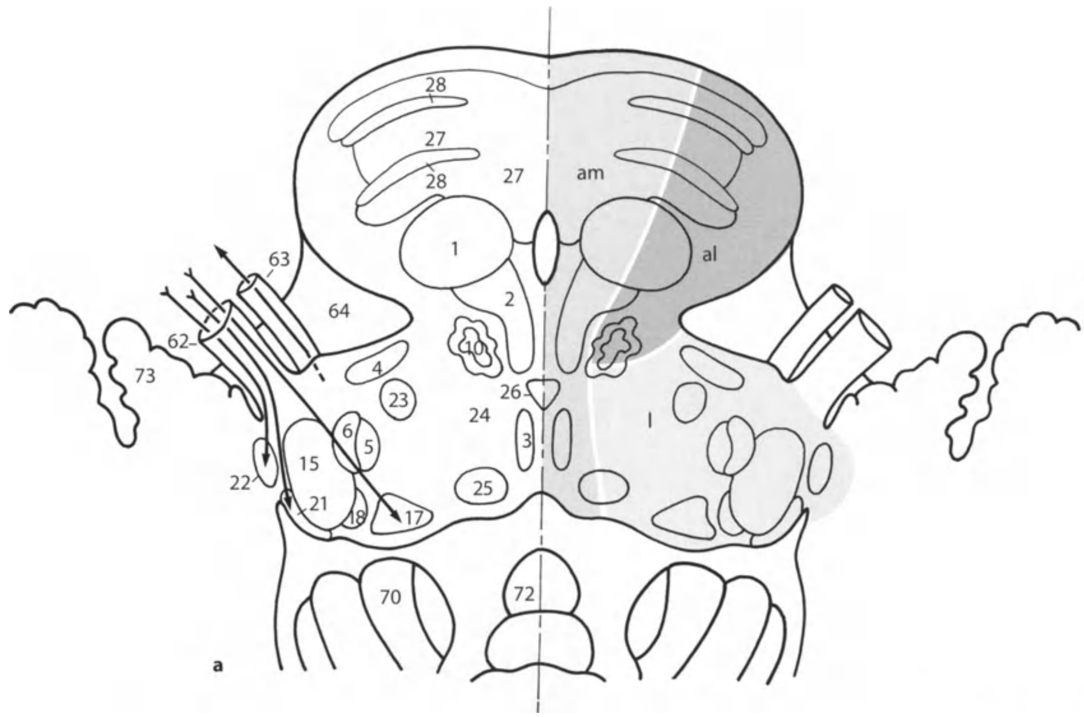
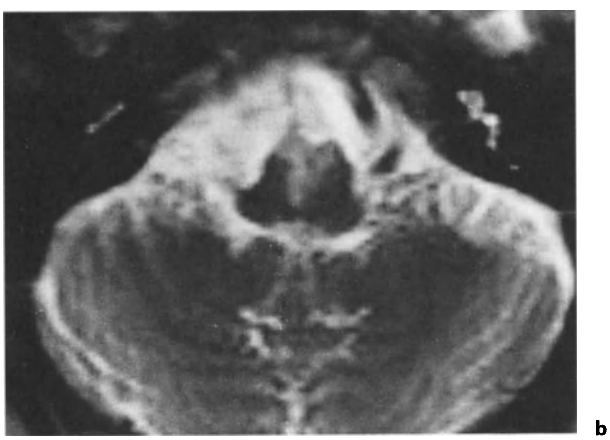


Fig. 180a. Transverse Section of the Medulla (middle level). For more information, see Fig. 26. *am*, anteromedial medullary territory; *al*, anterolateral medullary territory; *l*, lateral medullary territory; *p*, posterior medullary territory
b Infarct involving the anteromedial (*am*) medullary territory
c Infarct involving the lateral (*l*) medullary territory





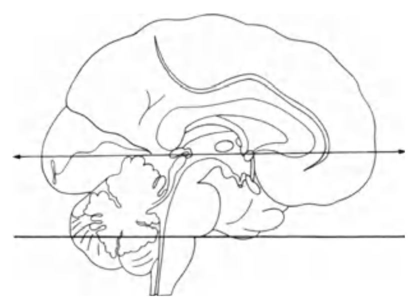
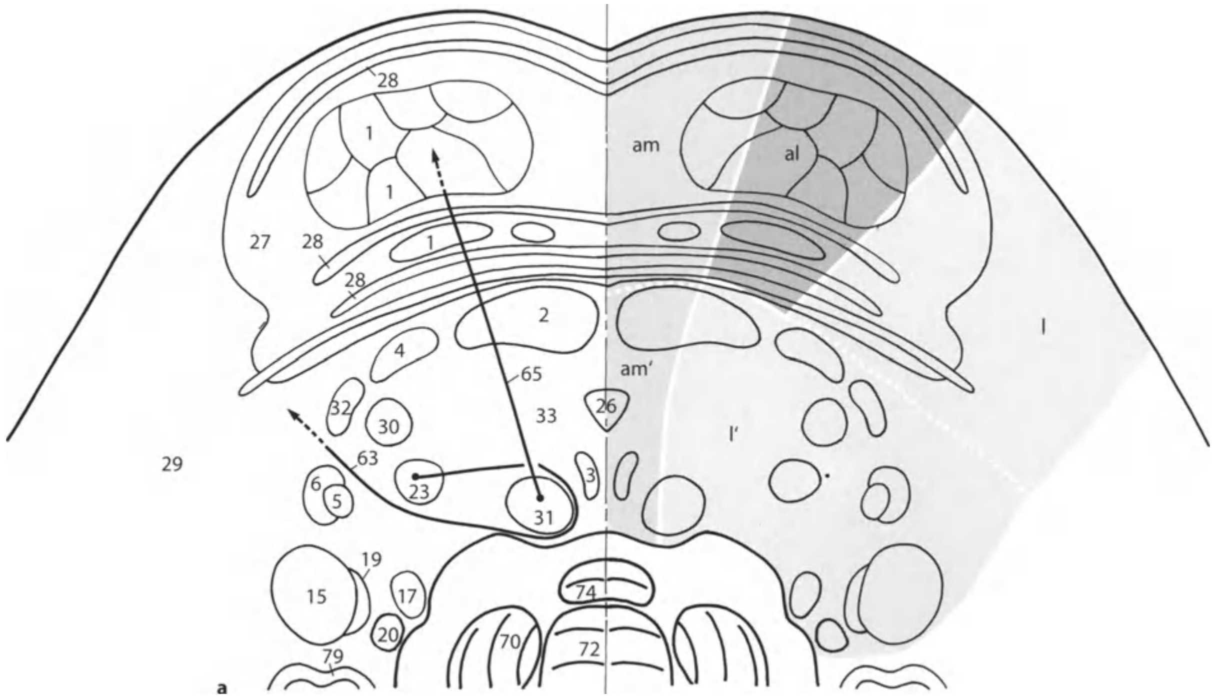


Fig. 181a. Transverse Section of the Medulla (pontomedullary junction). For more information, see Fig. 27. *am*, anteromedial medullary territory; *al*, anterolateral medullary territory; *l*, lateral medullary territory
b Infarct involving, on both sides, the anteromedial (*am*) medullary territories



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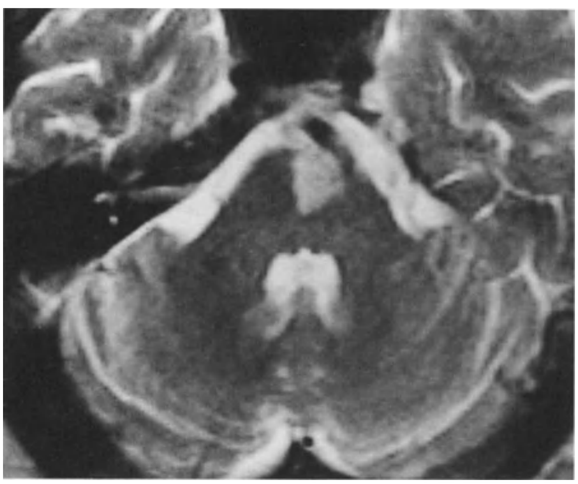

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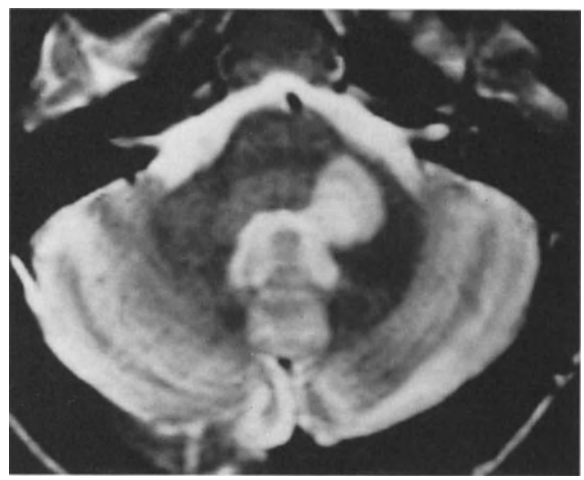

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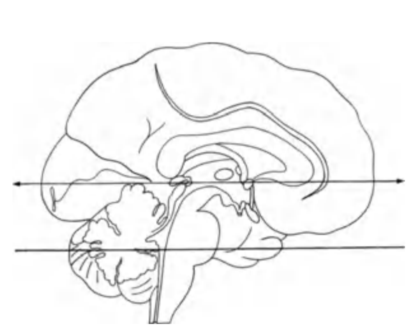
Fig. 182a. Transverse Section of the Pons (inferior level). For more information, see Fig. 28. *am*, anteromedial pontine territory; *am'*, anteromedial pontine territory (medial inferior pontine tegmentum) vascularized by the arteries of the foramen caoecum (see p. 42); *al*, anterolateral pontine territory; *l*, lateral pontine territory; *l'*, lateral pontine territory (lateral inferior pontine tegmentum) vascularized by the arteries of the pontomedullary sulcus (see p. 43 and 70)
b Infarct involving the anteromedial (*am*) pontine territory corresponding to the pontine basilar part and sparing the pontine tegmentum (*am'*)
c Infarct involving the lateral (*l* and *l'*) pontine territory



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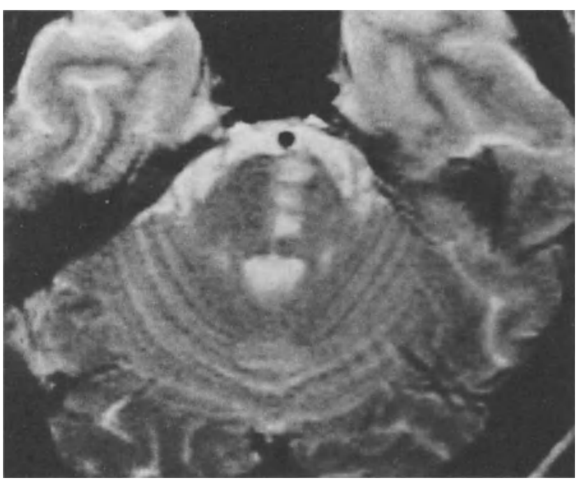

b

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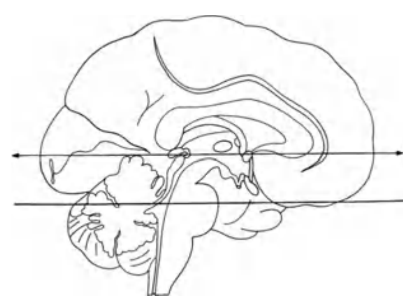
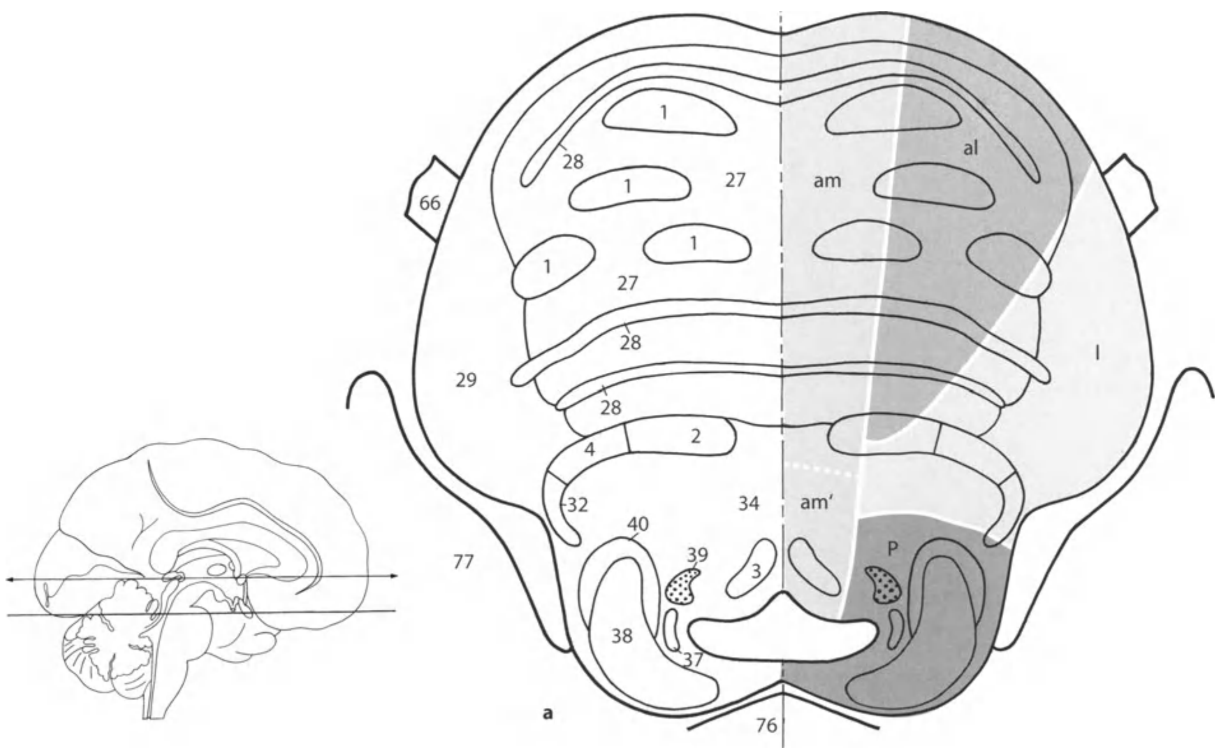
Fig. 183a. Transverse Section of the Pons (middle level). For more information, see Fig. 29. *am*, anteromedial pontine territory; *al*, anterolateral pontine territory; *l*, lateral pontine territory; *l'*, lateral pontine territory of the pontine tegmentum including the trigeminal nuclei vascularized by arteries following the trigeminal fibers; *p*, posterior territory
b Infarct involving the anteromedial (*am*) pontine territory
c Infarct involving the lateral (*l* and *l'*) and posterior (*p*) pontine territories





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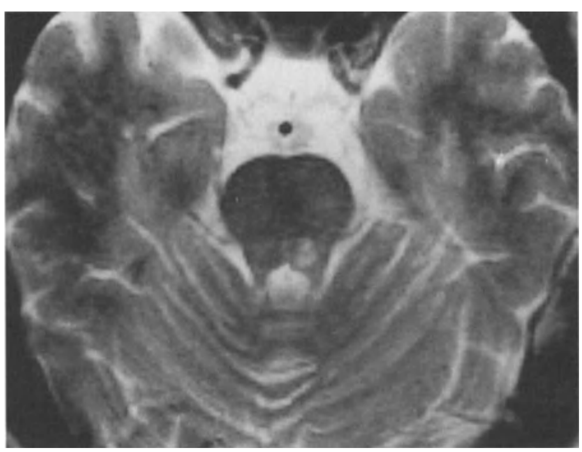

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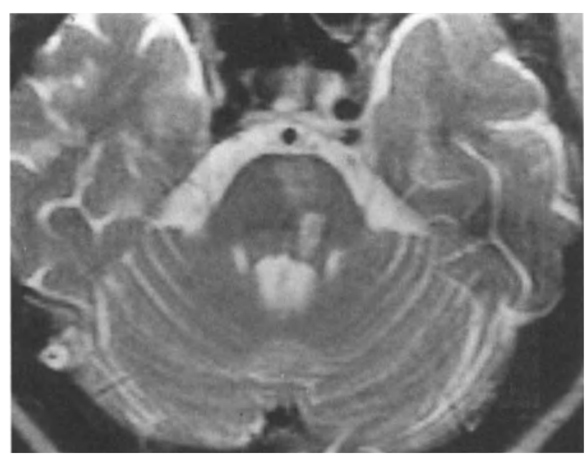

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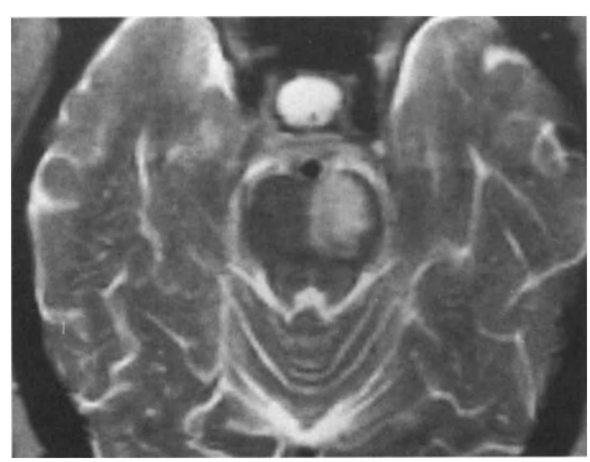
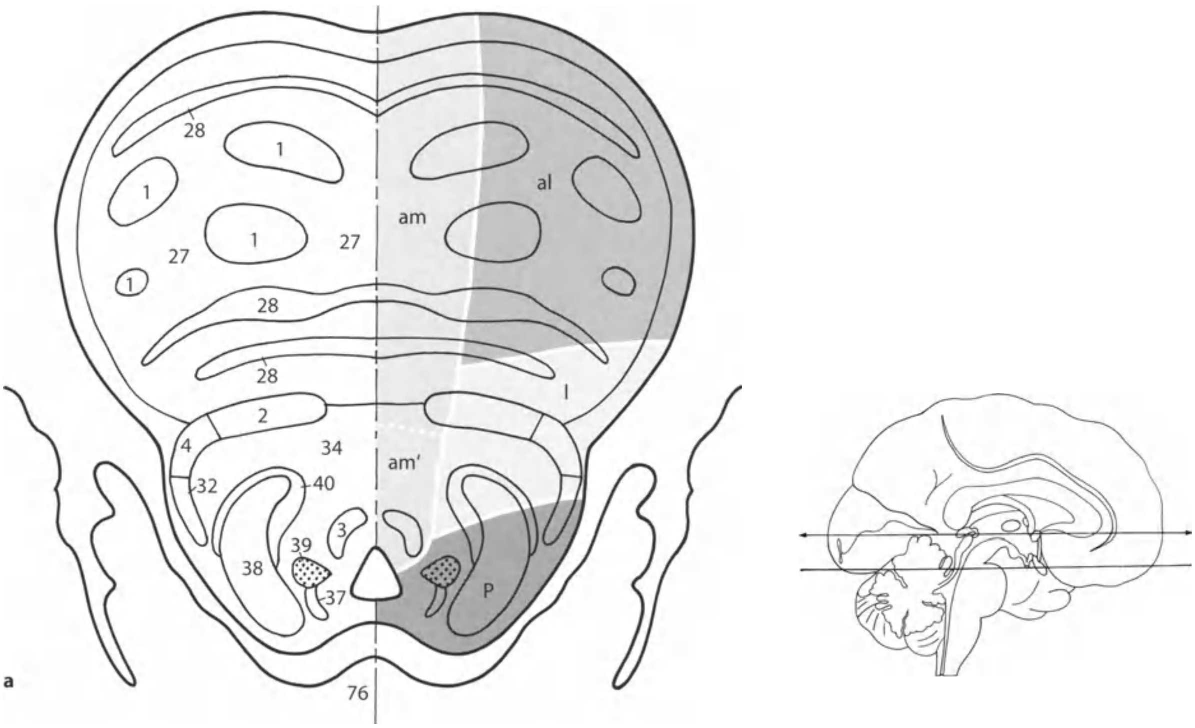


d

Fig. 184. Transverse Section of the Pons (superior level). For more information, see Fig. 30. *am*, anteromedial pontine territory; *am'*, anteromedial pontine territory (medial superior pontine tegmentum) vascularized by arteries of the interpeduncular fossa (see p. 70); *al*, anterolateral pontine territory; *l*, lateral pontine territory; *p*, posterior pontine territory
b Infarct involving the anteromedial (*am'*) territory in the pontine tegmentum and sparing the pontine basal part
c Infarct involving the anteromedial (*am*, *am'*) pontine territory
d Infarct involving the anteromedial (*am*) and anterolateral (*al*) pontine territories and sparing the pontine tegmentum



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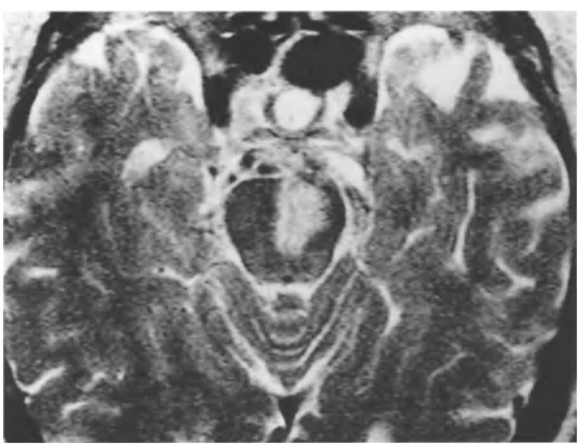

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Fig. 185a. Transverse Section of the Pons(superior level). For more information, see Fig. 31. *am*, anteromedial pontine territory; *am'*, anteromedial pontine territory (medial superior pontine tegmentum) vascularized by arteries of the interpeduncular fossa (see p. 70); *al*, anterolateral pontine territory; *p*, posterior pontine territory
b Infarct involving the anteromedial (*am*) and anterolateral (*al*) pontine territories and sparing the pontine tegmentum (*am'*)

▷

Fig. 186a. Transverse Section of the Mesencephalon (inferior level). For more information, see Fig. 32. *am*, anteromedial mesencephalic territory; *al*, anterolateral mesencephalic territory; *l*, lateral mesencephalic territory; *p*, posterior mesencephalic territory
b Infarct involving the anteromedial (*am*) mesencephalic territory
c Infarct involving the anteromedial (*am*) and anterolateral (*al*) mesencephalic territories
d Infarct involving the lateral (*l*) mesencephalic territory
e Infarct involving the lateral (*l*) and posterior (*p*) mesencephalic territories

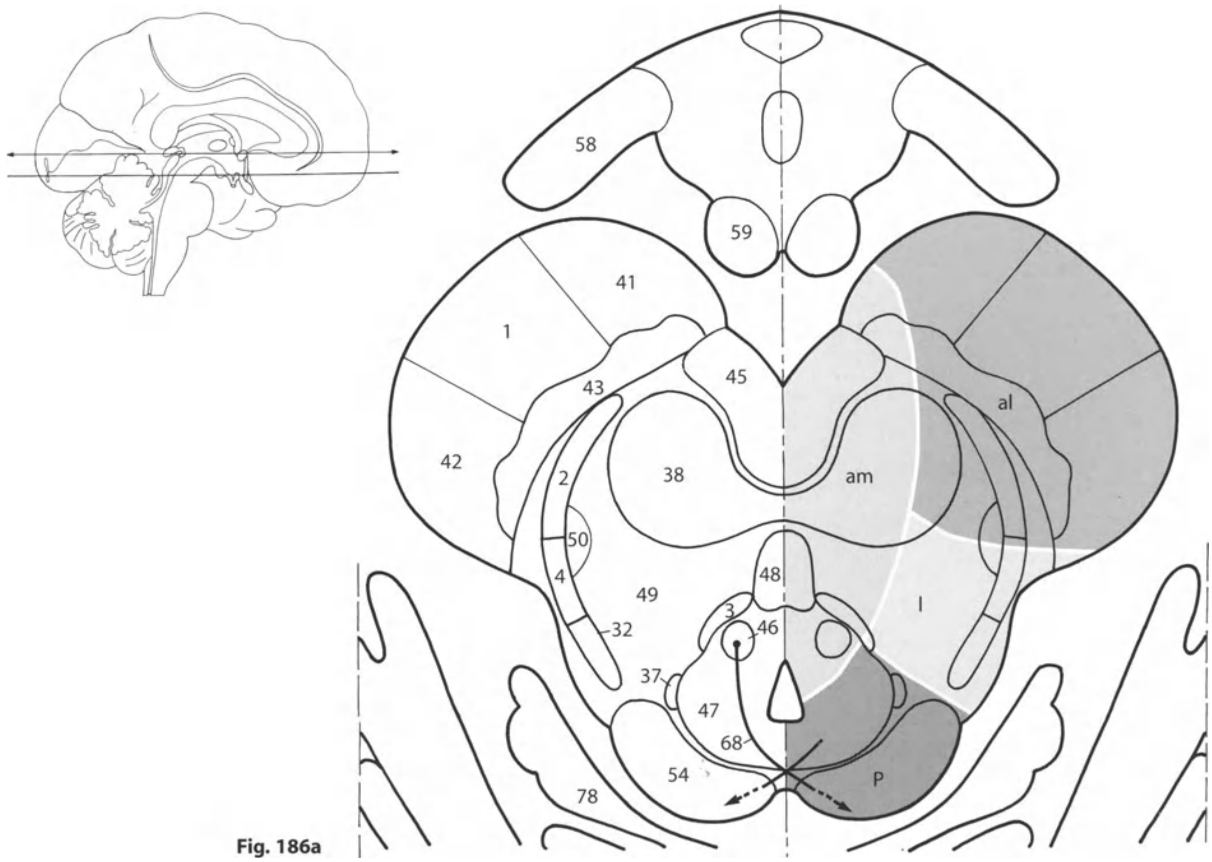
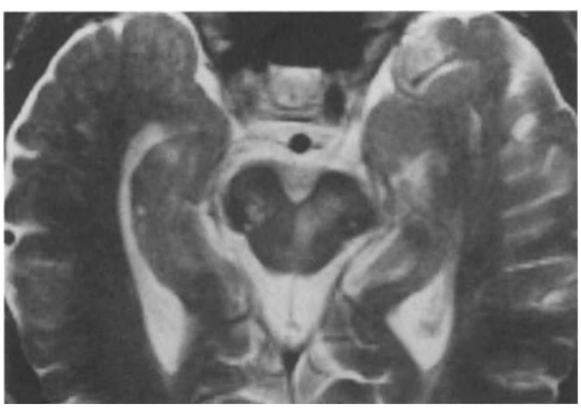


Fig. 186a



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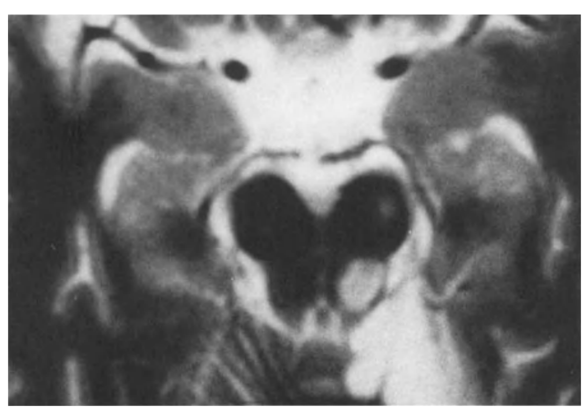

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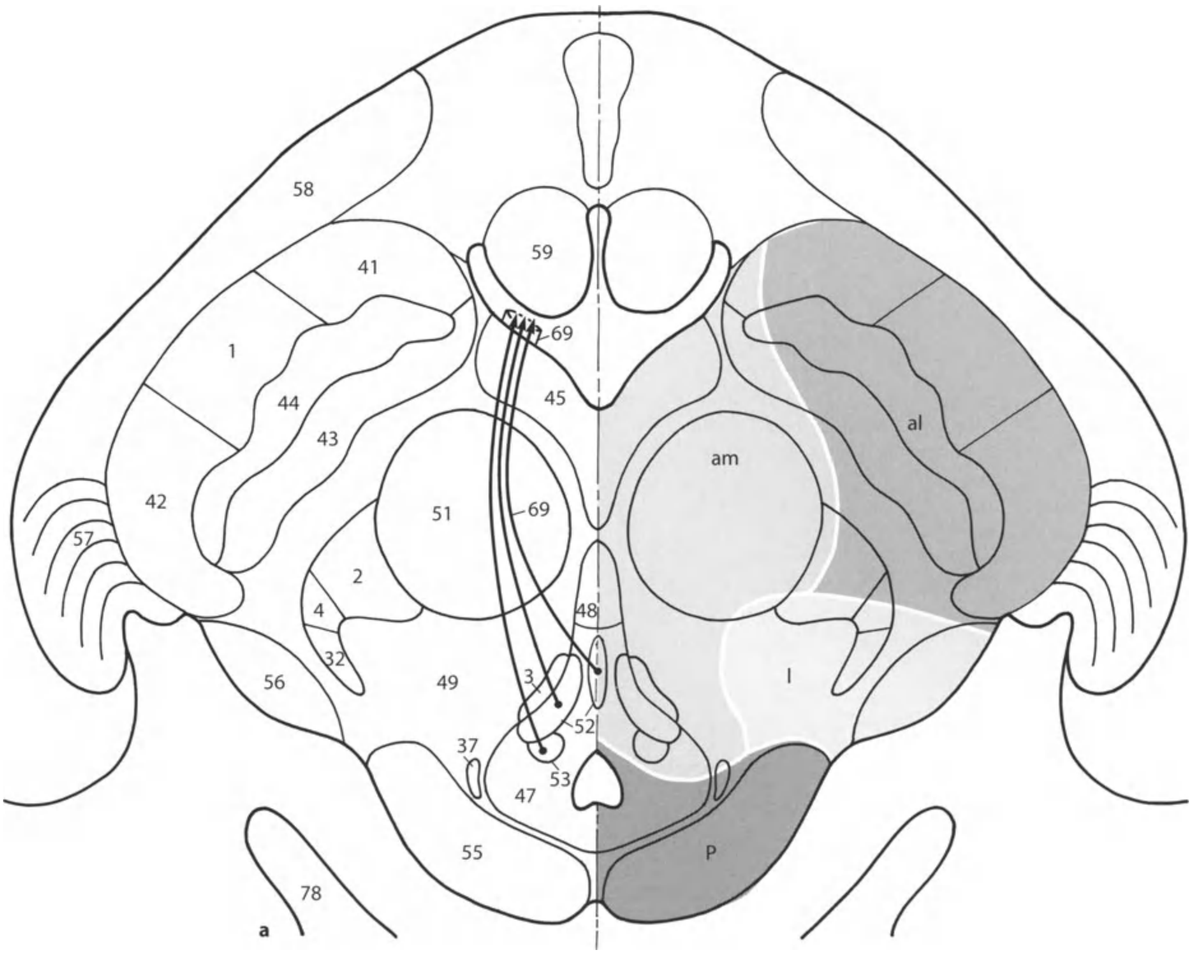

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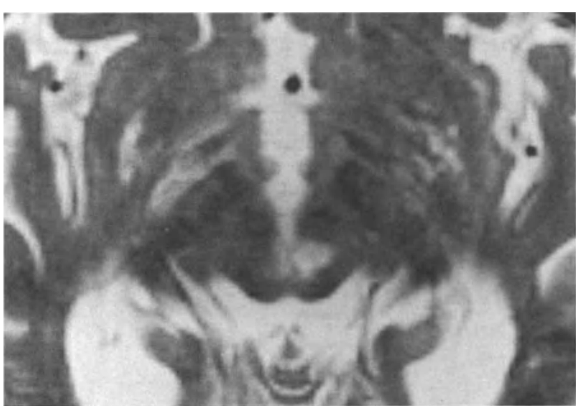

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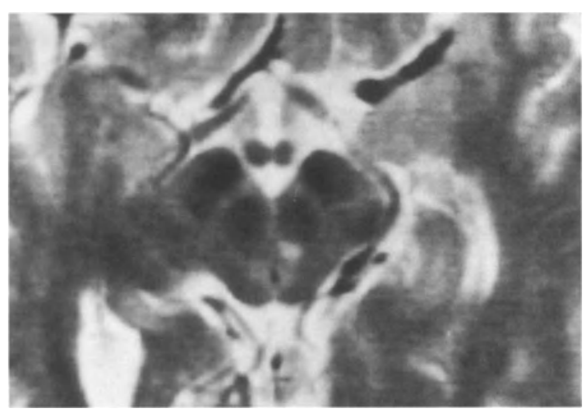
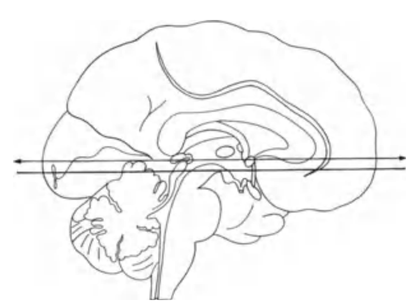


c

Fig. 187a. Transverse Section of the Mesencephalon (superior level). For more information, see Fig. 33. *am*, anteromedial mesencephalic territory; *al*, anterolateral mesencephalic territory; *l*, lateral mesencephalic territory; *p*, posterior mesencephalic territory
b Infarct involving the anteromedial (am) mesencephalic territory
c Infarct involving the anteromedial mesencephalic territory restricted to the tegmentum of the mesencephalon



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