THE ANATOMY OF THE CEREBROSPINAL NERVES OF THE FOX SQUIRREL, *SCIURUS NIGER RUFIVENTER* (GEOFFROY)

By

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A THESIS

Submitted to the School of Graduate Studies of Michigan State College of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Department of Zoology

1954

ACKNOWLEDGMENTS

The author is grateful for the aid given by the following persons of the guidance committee: Dr. R. A. Fennell, major professor and chairman of the committee; Dr. Calhoun, head of the Anatomy Department; Dr. W. D. Collings of the Physiology Department. Mrs. Bernadette Henderson (Miss Mac) deserves thanks for her words of encouragement and advice on many occasions. Dr. J. F. Smithcors of the Anatomy Department deserves special acknowledgment for critically reading the manuscript and offering help throughout the writing.

The author wishes to express his gratitude to Miss Esther M. Smith for the photographic work, and to Mr. A. Studer, a veterinary student, for the final preparation of the drawings. The Game Division deserves thanks for permitting the author to obtain specimens.

Special thanks is given to the author's wife and children for their constant encouragement and patience throughout the period of work.

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I. INTRODUCTION

Although there has been an increase in recent years in the interest of game management and conservation studies, the detailed anatomy of game animals has been neglected. There has been published very little detailed anatomy of the nervous system of rodents and other game animals. Greene (1935) gave some detailed descriptions on certain portions of the nervous system of the rat, but did not attempt to give a complete detailed account of the system. Hunt (1924) gave a very brief account of the spinal nerves of the rat.

This paper is a unit of anatomical study of this species which has been carried out by three candidates for degrees under the supervision of Dr. R. A. Fennell of the Zoology Department at Michigan State College. Orwoll (1940) described the osteology and myology of the fox squirrel, Mizeres (1950) described the anatomy of the autonomic nervous system of this species, and the author of this present study (Jenkins, 1950) described the anatomy of the blood vascular system of this same species.

It is the purpose of this study to present a description of the anatomy of the cerebrospinal nerves of the fox

squirrel, Sciurus niger rufiventer (Geoffroy), Michigan's largest tree squirrel (Burt, p. 192, 1946). This work is not a comparative study of this portion of the nervous system; but throughout the text, where appropriate, references are made to common mammals for the sake of comparison and aid in understanding. This study is confined to an anatomical description of the cerebrospinal nerves and plexuses. Any physiological aspects of the nervous system are considered beyond the scope of this work.

Each major division of this study has an introduction which pertains specifically to that division.

II. MATERIALS AND METHODS

Six fox squirrels (Sciurus niger rufiventer) were live-trapped in a woodlot on the campus of Michigan State College. These animals were embalmed and their blood-vascular systems injected with latex at the General Biological Supply House in Chicago. In addition to the embalmed specimens, freshly killed specimens were periodically used for checking various dissections. Almost all dissecting was performed under a dissecting microscope, using 9X magnification.

Twenty-one figures of various dissections are presented in addition to the descriptions. The figures are pen and ink tracings of the original drawings made at the time of dissection. The figures were drawn according to the scale given in each case. In the figures the spinal nerves are lettered and the cranial nerves are usually labeled by Roman numerals. In the text the letter and figure-number given after each nerve refers to the illustration of that specific nerve.

A graphic view 4 X 5 inch camera was used for the photography. The photographs were taken with Kodak contrast process panchromatic film, developed in contrast developer, and printed on Kodabromide A-4 paper.

III. THE CRANIAL NERVES

The twelve pairs of cranial nerves of the fox squirrel show no special features with regard to their connections with the brain. According to the typical mammalian pattern, the cranial nerves are attached to the brain in numerical order proceeding from rostral to caudal ends of the brain as shown in figure 1 and described below. The cranial nerves leave the cranium through foramina at the base of the skull. Most of the cranial nerves are confined in their distribution to the head and neck regions. The exceptions, as described below, are the spinal accessory nerve (XI), which passes to the trapezius muscles; and the vagus (X), which extends caudad to the thoracic and abdominal viscera.

The cranial foramina in the fox squirrel are not exactly the same as those so well described for other mammalian species. Orwoll (pp. 5-34, 1940) made no attempt to describe the foramina of the squirrels he studied. Greene (pp. 5-29, 1935) named foramina of the rat skull, but disagreed with Hill (1935) in some instances, e.g., the "anterior lacerated foramen" of the rat according to Greene (p. 116, 1935) by definition is identical to the "sphenoidal fissure" of

FIGURE 1. BASAL ASPECT OF THE BRAIN

I. Olfactory bulb

II. Optic N. (at chiasma)

III. Oculomotor N.

IV. Trochlear N.

V. Trigeminal N.
- A. Ophthalmic N.
- B. Maxillary N.
- C. Mandibular N.
- D. Semilunar Ganglion
- E. Portio minor

VI. Abducens N.

VII. Facial N.

VIII. Acoustic N.

IX. Glossopharyngeal N.

X. Vagus N.

XI. Spinal Accessory N.

XII. Hypoglossal N.

C-1. First Cervical N.

1. Cerebral Hemisphere

2. Infundibulum (cut)

3. Pons

4. Trapezium

5. Cerebellum

6. Paraflocculus

7. Pyramid

8. Spinal Cord

9. Basilar A.

10. Internal Carotid A.

11. Middle Cerebral A.

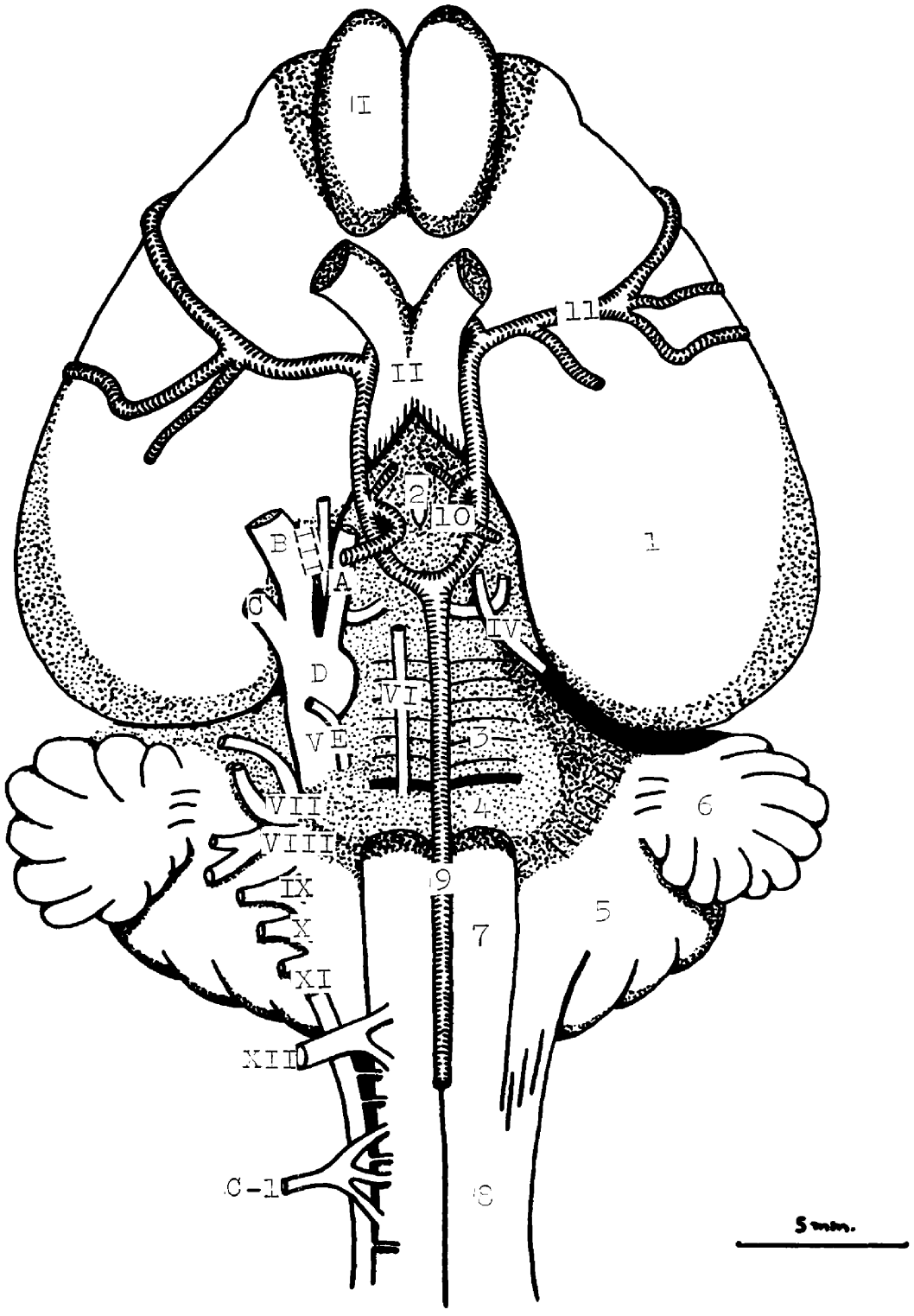
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FIGURE 1. BASAL ASPECT OF THE BRAIN

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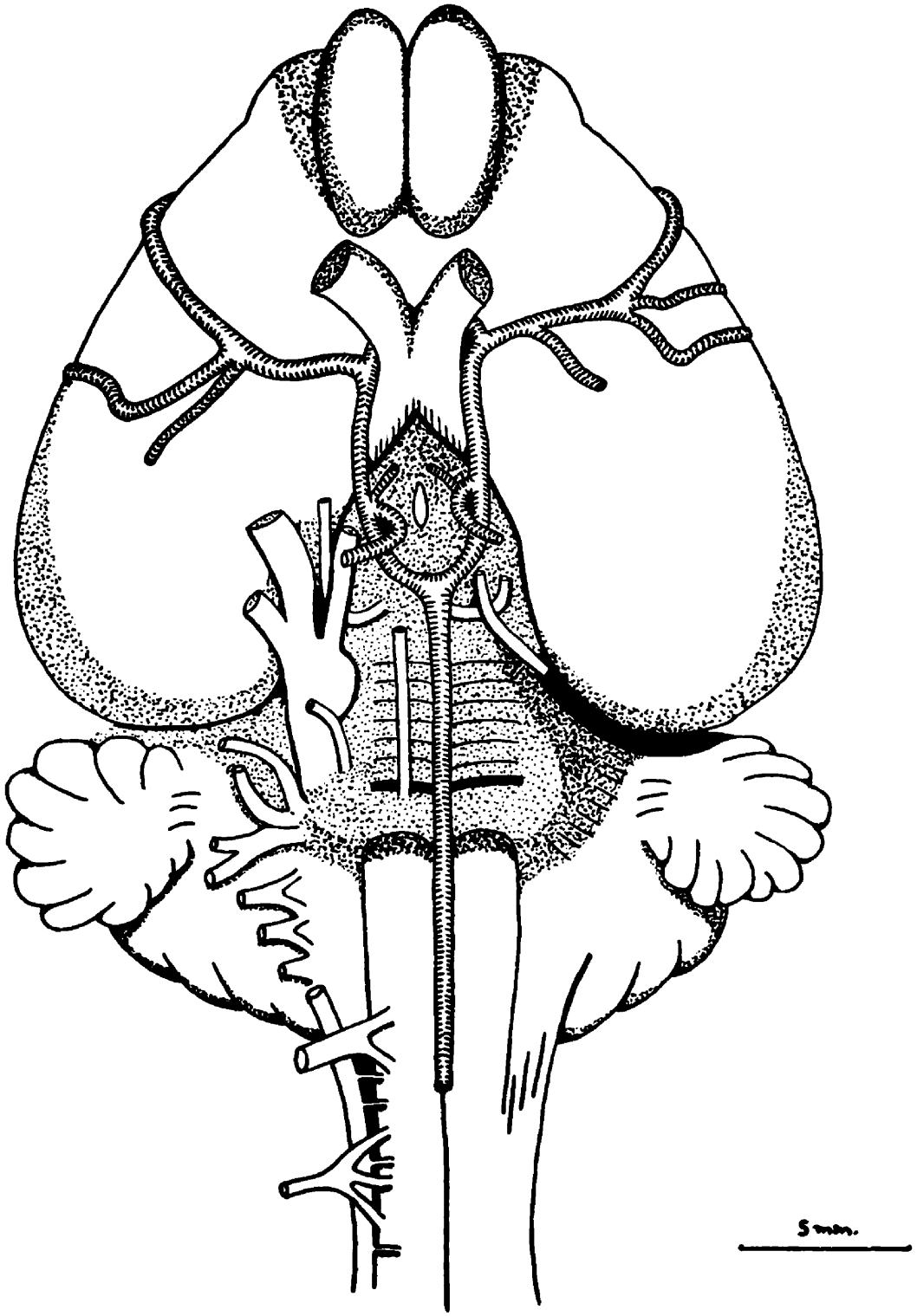
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rodents as defined by Hill (p. 124, 1935). In this work the term "anterior lacerated foramen" is usually used in order to distinguish this foramen from the "posterior lacerated foramen" as used below under the ninth, tenth, and eleventh cranial nerves. In some rodents, including the fox squirrel, the cranial foramina through which pass the divisions of the trigeminal nerve are different from those of other mammalian species. These differences are discussed under the trigeminal nerve.

The following description of the cranial nerves, and all other nerves in this work, is strictly anatomical in nature; any implications of functional components of the nerves is considered beyond the scope of this work. The nerves are described separately in numerical order. Beneath each heading is the figure, or figures, which illustrate the nerve under consideration. In the description of an individual nerve or branch, specific references to detailed structures in the figures are inserted.

I. OLFACTORY NERVE

(Fig. 1)

The Olfactory Nerve arises in the nasal mucous membrane. This nerve is a compound nerve, consisting of many filaments which pass centripetally through the cribriform plate of the ethmoid bone to terminate in the olfactory bulb of the brain (I, fig. 1).

II. OPTIC NERVE

(Figs. 1,2,4,5)

The Optic Nerve is a large nerve which passes from the posterior portion of the eyeball in a caudomedio-oblique direction through the orbit to make its exit through the optic foramen. The optic nerve is completely enveloped by the extrinsic muscles of the eye and can be seen only by separating or transecting some of these muscles (figs. 2,4,5). At the caudal portion of the orbit, the optic nerve is in close association with the cranial nerves innervating the extrinsic eye muscles, ciliary ganglion and nerves, and nerves entering the orbit through the anterior lacerated foramen as shown in figure 5. The optic nerve passes into the cranial cavity to continue its course to the ventral surface of the diencephalic portion of the brain where it meets its counterpart from the opposite side to form the optic chiasma as shown in figure 1.

III. OCULOMOTOR NERVE

(Figs. 1,2,4,5)

The Oculomotor Nerve arises from the base of the mesencephalic portion of the brain near the mid-line at the level of the cerebral peduncles. This third cranial nerve loops laterad and rostrally to pass from the cranium into the orbit by way of the anterior lacerated foramen. Within the orbit this nerve innervates the dorsal (superior), medial,

FIGURE 2. A SUPERFICIAL DISSECTION OF THE RIGHT EYE (VENTROLATERAL VIEW)

A. Abducens N.

B. Oculomotor N. (ventral division)

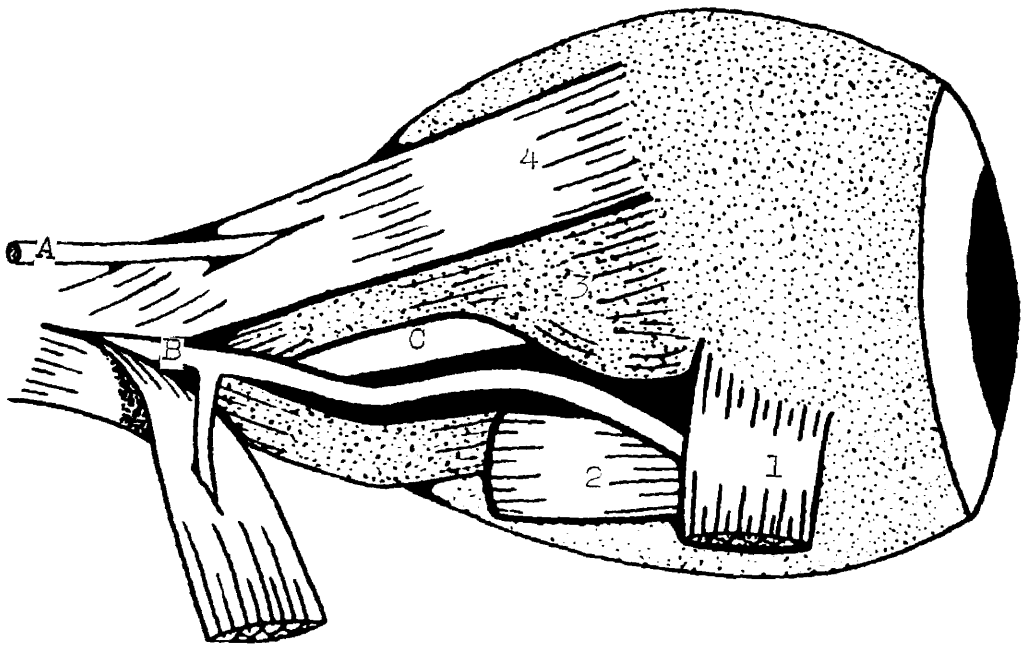
C. Optic N.

1. Ventral Oblique M.

2. Ventral Rectus M.

3. Retractor Oculi M.

4. Lateral Rectus M.



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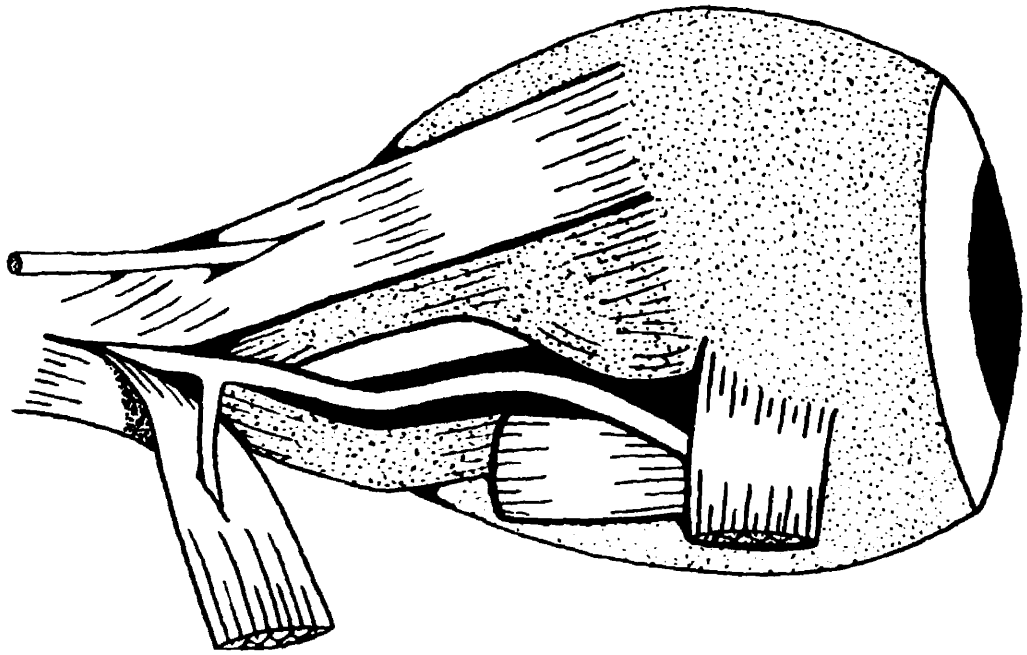

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FIGURE 3. A SUPERFICIAL DISSECTION OF THE RIGHT EYE (DORSAL VIEW)

A. Lacrimal N.
B. Abducens N.
C. Trochlear N.
D. Frontal N.
E. Nasociliary N.

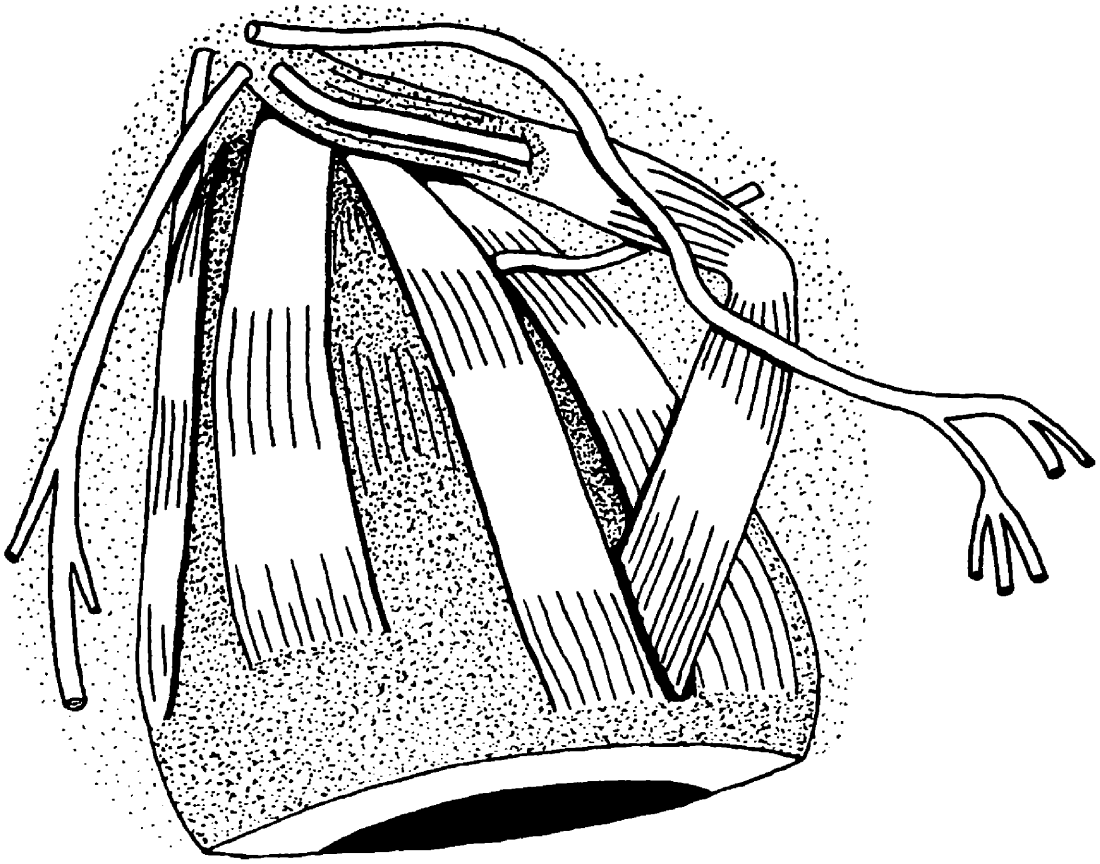
1. Lateral Rectus M.
2. Dorsal Rectus M.
3. Retractor Oculi M.
4. Dorsal Levator Palpebral M.
5. Medial Rectus M.
6. Dorsal Oblique M.

5mm

FIGURE 3. A SUPERFICIAL DISJECTION OF THE RIGHT EYE (DORSAL VIEW)

A. Lacrimal N.
B. Abducens N.
C. Trochlear N.
D. Frontal N.
E. Nasociliary N.

1. Lateral Rectus M.
2. Dorsal Rectus M.
3. Retractor Oculi M.
4. Dorsal Levator Palpebral M.
5. Medial Rectus M.
6. Dorsal Oblique M.



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and ventral (inferior) recti muscles, and the ventral (inferior) oblique muscle as described below. After entering the orbit, the nerve bifurcates into the following:

A) Dorsal (Superior) Division

B) Ventral (Inferior) Division

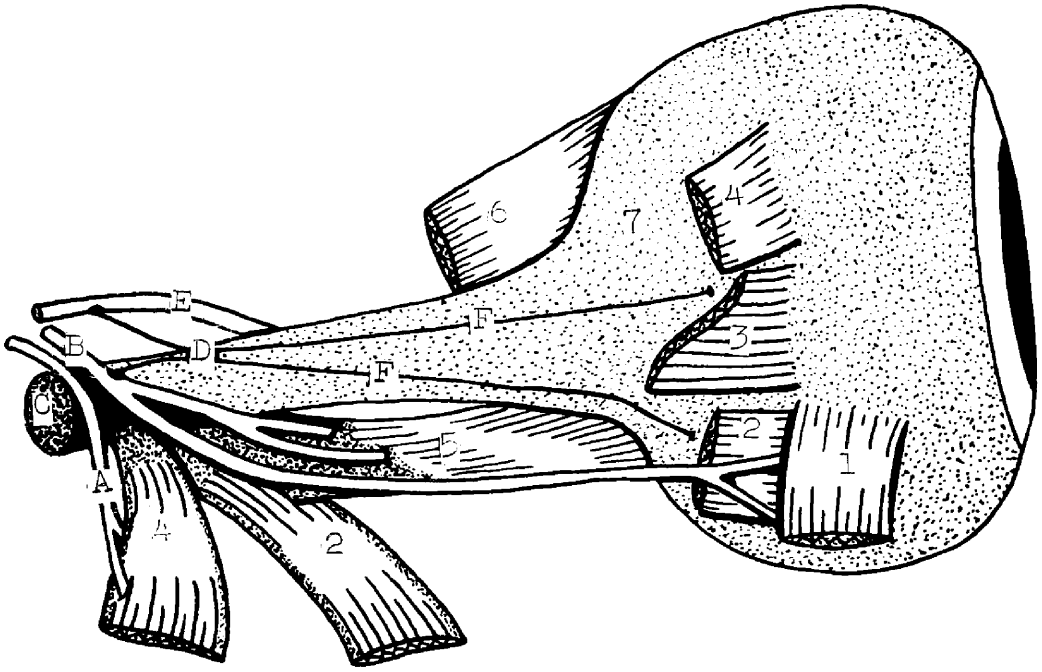
A) The Dorsal Division of the oculomotor nerve is the smaller portion which passes directly to the ocular surfaces of the m. rectus dorsalis and m. levator palpebrae superioris.

B) The Ventral Division of the oculomotor nerve (B, fig. 2; B, fig. 4; E, fig. 5) is much larger and longer than the dorsal division. The ventral division passes laterad to the optic nerve between the nasociliary and abducens nerves, ventrad to the former and dorsad to the latter as illustrated in figures 4 and 5. A few millimeters after its entrance into the orbit, this inferior division of the oculomotor nerve gives rise to a prominent branch which passes directly to the ocular surface of the m. rectus medialis (5, fig. 4; 4, fig. 5). The lateral ramus of this bifurcation continues distally for a few millimeters before dividing to send one branch to the muscle rectus ventralis; whereas the other ramus continues distally to innervate the ventral oblique muscle (1, fig. 2; 1, fig. 4) close to its insertion, superficial to the insertion of the ventral rectus muscle as illustrated in the figures. The bifurcation of the oculomotor nerve into dorsal (superior) and ventral (inferior) divisions with their terminal innervations is similar to that of the human

FIGURE 4. DEEP DISSECTION OF THE RIGHT EYE
(VENTROLATERAL VIEW)

A. Abducens N.
B. Oculomotor N. (ventral div.)
C. Optic N.
D. Ciliary Ganglion
E. Nasociliary N.
F. Short Ciliary N.

1. Ventral Oblique M.
2. Ventral Rectus M.
3. Retractor Oculi M. (section, cut)
4. Lateral Rectus M.
5. Medial Rectus M.
6. Dorsal Rectus M.
7. Sclera



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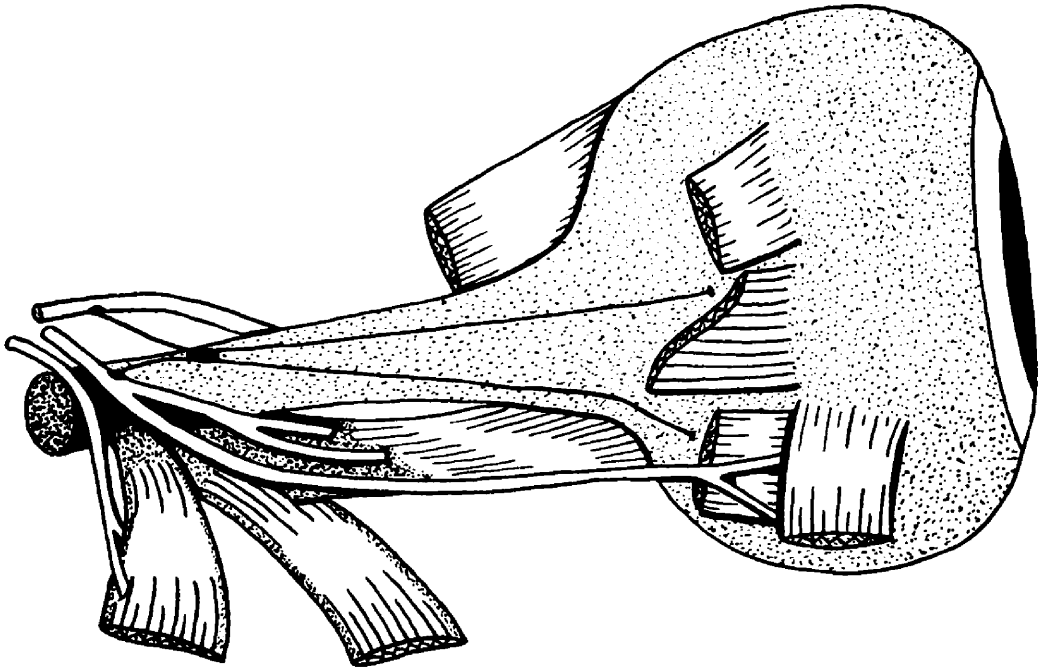
7. Sclera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according to Kronfeld (p. 37, 1944), and similar to that of the horse (Sisson, p. 814, 1953). The short ciliary nerves and the ciliary ganglion are a portion of the autonomic nervous system, but are considered here because they are in such close association with the innervation of the eye and its adnexa as described and illustrated in this work. Near its entrance into the orbit the ventral division of the third cranial nerve gives off a very delicate ramus to the ciliary ganglion (D, fig. 4; G, fig. 5). Proximal to the ciliary ganglion, there is also a very small ramus from the nasociliary branch of the ophthalmic division of the trigeminal nerve as stated in the description of that nerve. Distally the ciliary ganglion gives rise to two short ciliary nerves (F, fig. 4; F, fig. 5) which proceed to pierce the sclera of the eyeball. The fox squirrel is similar to the cat with respect to having only two ciliary nerves (Reighard and Jennings, p. 370, 1940); whereas the monkey (Christensen, p. 294, 1933) and man (Kronfeld, p. 55, 1944) have several short ciliary nerves.

IV. TROCHLEAR NERVE

(Figs. 1,3,5)

The Trochlear Nerve appears on the ventral surface of the brain immediately anterior to the region of the brachium conjunctivum as illustrated in figure 1. The trochlear nerve proceeds rostrally to pass through the anterior lacerated

FIGURE 5. DETAILED DISSECTION OF THE RIGHT ANTERIOR LACERATED FORAMEN

(LATERAL VIEW)

A. Lacrimal N. (reflected ventrally)

B. Abducens N.

C. Maxillary Division of Trigeminal N.

D. Optic N.

E. Oculomotor N. (ventral division)

F. Short Ciliary N.

G. Ciliary Ganglion

H. Ramus from III to Ciliary Ganglion

I. Nasociliary N.

J. Ramus from Nasociliary N. to Ciliary Ganglion

K. Oculomotor N. (dorsal division)

L. Trochlear N.

M. Frontal N.

1. Lateral Rectus M.

2. Ventral Rectus M.

3. Retractor Oculi M.

4. Medial Rectus M.

5. Dorsal Rectus M.

6. Anterior Lacerated Foramen

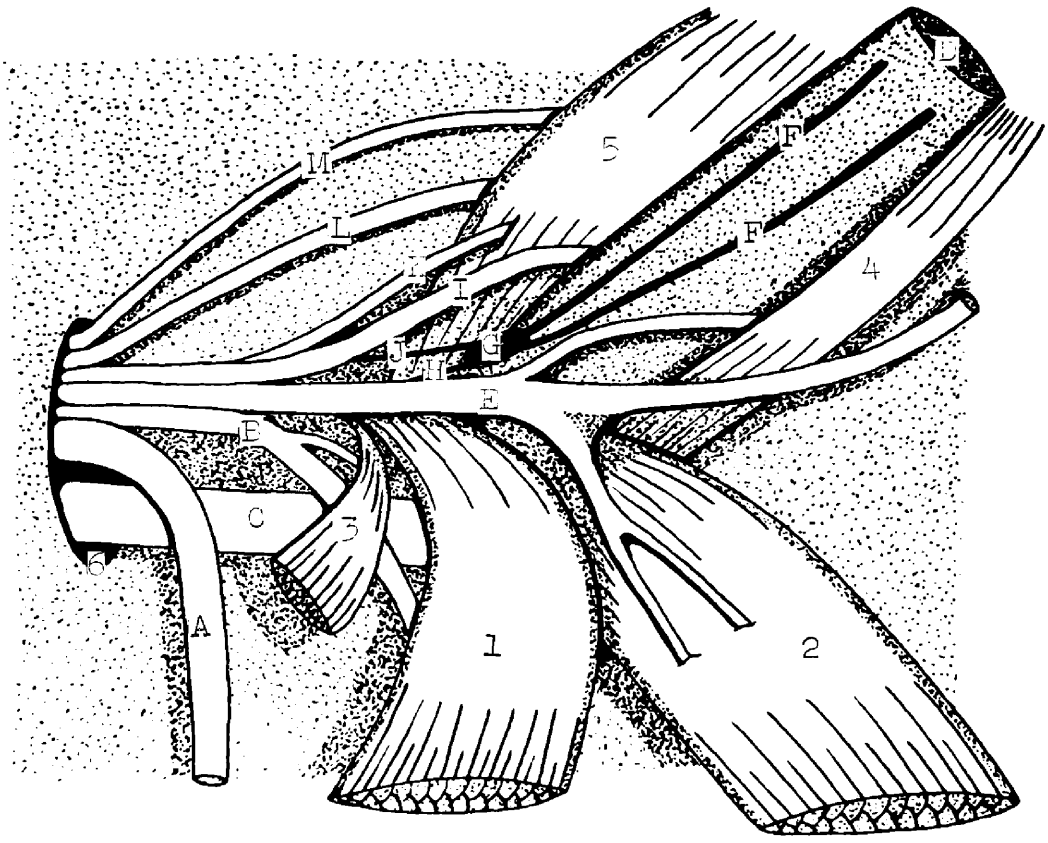
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FIGURE 5. DETAILED DISSECTION OF THE RIGHT ANTERIOR LACERATED FORAMEN

(LATERAL VIEW)

A. Lacrimal N. (reflected ventrally)

B. Abducens N.

C. Maxillary Division of Trigeminal N.

D. Optic N.

E. Oculomotor N. (ventral division)

F. Short Ciliary N.

G. Ciliary Ganglion

H. Ramus from III to Ciliary Ganglion

I. Nasociliary N.

J. Ramus from Nasociliary N. to Ciliary Ganglion

K. Oculomotor N. (dorsal division)

L. Trochlear N.

M. Frontal N.

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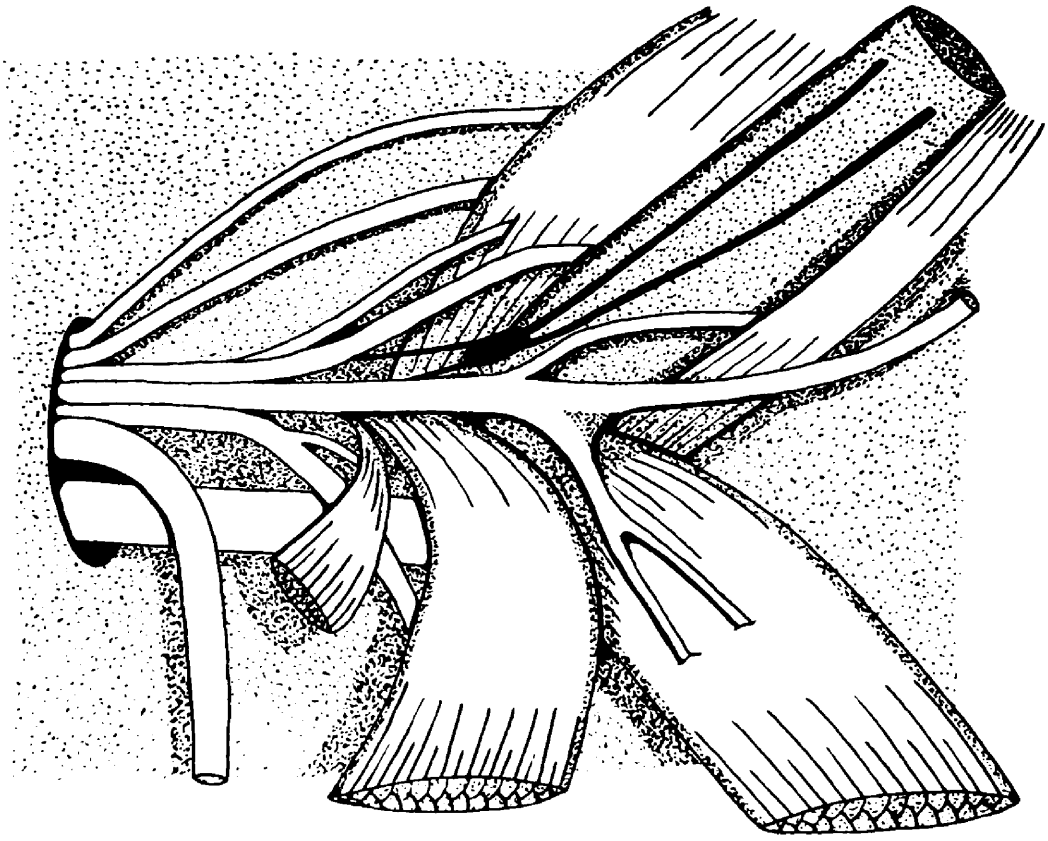
6. Anterior Lacerated Foramen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foramen in very close association with the other nerves as shown in detail in figure 5. At this location the trochlear nerve (L, fig. 5) is between the frontal branch of the ophthalmic division of the trigeminal nerve (M, fig. 5) and the dorsal division of the oculomotor nerve (K, fig. 5); ventrad to the former and dorsad to the latter. The trochlear nerve passes dorsomediad to innervate the m. obliquus superior near its origin as shown in figure 3. This is the only extrinsic muscle of the eye innervated by this nerve.

V. TRIGEMINAL NERVE

(Fig. 1)

The Trigeminal Nerve (V, fig. 1) arises from the caudal border of the pons by two roots. The one root is very large, and shortly after its departure from the lateral part of the pons it has an enlargement, the Semilunar or Gasserian ganglion. The other root is small and has no such ganglion. Distal to the semilunar ganglion there are three divisions of the large root:

1. Ophthalmic
2. Maxillary
3. Mandibular

The smaller root of the trigeminal nerve mentioned above follows the mandibular portion of the larger root.

As was pointed out in the introduction to the cranial nerves, the cranial foramina of the fox squirrel are not

exactly the same as those in other mammalian species. Probably the most obvious difference in the cranial foramina in the fox squirrel, when compared with common mammalian species, is the presence of a large foramen immediately caudad to the anterior lacerated foramen (sphenoidal fissure). Hill (1935) proposed the name "masticatory foramen" for a similarly located foramen found in some rodents. Based upon the above reference, the name "masticatory foramen" is used in this paper to denote the foramen through which passes the anterior trunk of the mandibular division of the trigeminal nerve.

1. The Ophthalmic Nerve (A, fig. 1) arises from the semilunar ganglion as the most dorsad and rostrad of the three divisions of the larger root of the trigeminal nerve. The ophthalmic nerve passes rostrally into the orbit by way of the anterior lacerated foramen. As this nerve leaves the foramen, it is intimately associated with the third, fourth and sixth cranial nerves, and the maxillary division of the fifth cranial nerve which also pass through the same foramen. As the ophthalmic nerve passes through this foramen, it gives rise to the following branches:

a) Lacrimal

b) Frontal

c) Nasociliary

a) The Lacrimal Nerve (A, fig. 3; A, fig. 5) enters the orbit after it passes through the anterior lacerated foramen. As shown in figure 5, this nerve lies dorsad to the

maxillary division of the trigeminal and ventrolaterad to the abducens nerve. The lacrimal nerve traverses along the lateral periorbita giving rise to rami which pass to the lacrimal gland. It then turns laterad to leave the orbit and ramify in the area between the eye and the base of the pinna of the ear.

b) The Frontal Nerve (D, fig. 3; M, fig. 5) enters the orbit as the most dorsal nerve which passes through the anterior lacerated foramen. This nerve follows the dorsomedial bony wall of the orbit dorsal to the proximal half of the dorsal oblique muscle. Immediately distad to the trochlea the frontal nerve crosses the dorsal oblique muscle to leave the orbit and distribute supratrochlear nerves to the muscles of the upper eyelid and surrounding integument of the forehead.

c) The Nasociliary Nerve (E, fig. 3; E, fig. 4; I, fig. 5) enters the orbit after emerging from the anterior lacerated foramen between the dorsal (K, fig. 5) and ventral (E, fig. 5) divisions of the oculomotor nerve. The nasociliary nerve passes dorsad to cross the optic nerve deep to the extrinsic eye muscles, before emerging dorsally to cross the medial rectus muscle. The nerve then passes through the ethmoidal foramen in the medial wall of the orbit to enter the cranial cavity. The nerve then pierces the cribriform plate of the ethmoid bone to reach the nasal cavity. Shortly after its entrance into the orbit the nasociliary nerve gives rise to

a very fine ramus (J, fig. 5) which passes to the ciliary ganglion. The ciliary ganglion and short ciliary nerves as seen in deep dissection (figs. 4 and 5) are components of the autonomic nervous system. They are considered briefly in this work under the oculomotor nerve.

2. The Maxillary Nerve (B, fig. 1; C, fig. 5) leaves the semilunar ganglion as the middle root as shown in figure 1. This nerve leaves the skull through the anterior lacerated foramen ventral to the ophthalmic branches to traverse rostrally through the infraorbital groove. Along its course the nerve separates into a number of nerves of which most emerge from the infraorbital fissure before fanning out to send branches to the side of the nose and the upper and lower lips, as discussed in detail under the infraorbital nerves. The maxillary division of the trigeminal nerve gives rise to the following nerves:

a) Zygomatic

b) Infraorbital

c) Sphenopalatine

a) The Zygomatic Nerve arises from the maxillary division as it passes through the anterior lacerated foramen. This nerve passes in a laterodorsad direction to distribute branches to the lateral side of the lower eyelid and superficial surface of the cheek.

b) The Infraorbital Nerves are multiple nerves which pass rostrally through the pterygopalatine fossa within the

infraorbital groove, ventral to the eyeball and its extrinsic muscles. The nerves traverse the infraorbital canal and emerge from it to distribute numerous branches to the integument in the area of the vibrissae of the upper lip, and to the wing of the nostril.

c) The Sphenopalatine Nerve leaves the maxillary division of the trigeminal nerve from the medial side proximal to the sphenopalatine foramen. At the level of the foramen, the infraorbital groove turns slightly laterad and dorsad to enter the infraorbital fissure. Just prior to entering the large sphenopalatine foramen, the sphenopalatine nerve gives rise to the greater palatine nerve which enters the posterior palatine canal to pass ventrally to reach the hard palate.

At the entrance of the foramen there is an elongated enlargement, the sphenopalatine ganglion. This is one of the autonomic ganglia of the head associated with the trigeminal nerve. As stated previously, the consideration of the autonomic nervous system is beyond the scope of this work. For anatomical detail of these ganglia as found in the fox squirrel, the reader is referred to the work of Mizeres (pp. 3-9, 1950).

3. The Mandibular Nerve (C, fig. 1) leaves the semilunar ganglion as the most ventral division of the larger portion of the fifth cranial nerve as shown in figure 1. Immediately distal to the ganglion the mandibular nerve is joined by the small root (portio minor) of the trigeminal nerve.

In the fox squirrel, the mandibular nerve divides into two portions while still within the cranium:

A) Posterior Trunk

B) Anterior Trunk

The fact that in the fox squirrel these trunks leave the cranium through separate foramina is peculiar when compared with the human (Gray, p. 885, 1936), rat (Greene, p. 117, 1935), cat (Reighard and Jennings, p. 373, 1940), and dog (Miller, p. 291, 1952) in which cases the mandibular division of the fifth cranial nerve divides into its subdivisions after the nerve emerges from the skull as a single unit through the foramen ovale.

A) The Posterior Trunk (fig. 6) of the mandibular nerve leaves the cranium through the foramen ovale and immediately gives rise to the following nerves:

a) Auriculotemporal

b) Lingual

c) Inferior Alveolar

d) Mylohyoid

a) The Auriculotemporal Nerve (B, fig. 6) passes in a caudodorsad direction to distribute branches to the muscles and integument in the area of the anterior auricular and superficial temporal arteries as shown by the author in a study of the blood vascular system of the fox squirrel (Jenkins, p. 35, and fig. 5, p. 33, 1950).

FIGURE 6. THE POSTERIOR TRUNK OF THE MANDIBULAR DIVISION OF THE TRIGEMINAL NERVE

(VENTROLATERAL VIEW, RIGHT SIDE)

A. Chorda Tympani N.

B. Auriculotemporal N.

C. Mylohyoid N.

D. Inferior Alveolar N.

E. Lingual N.

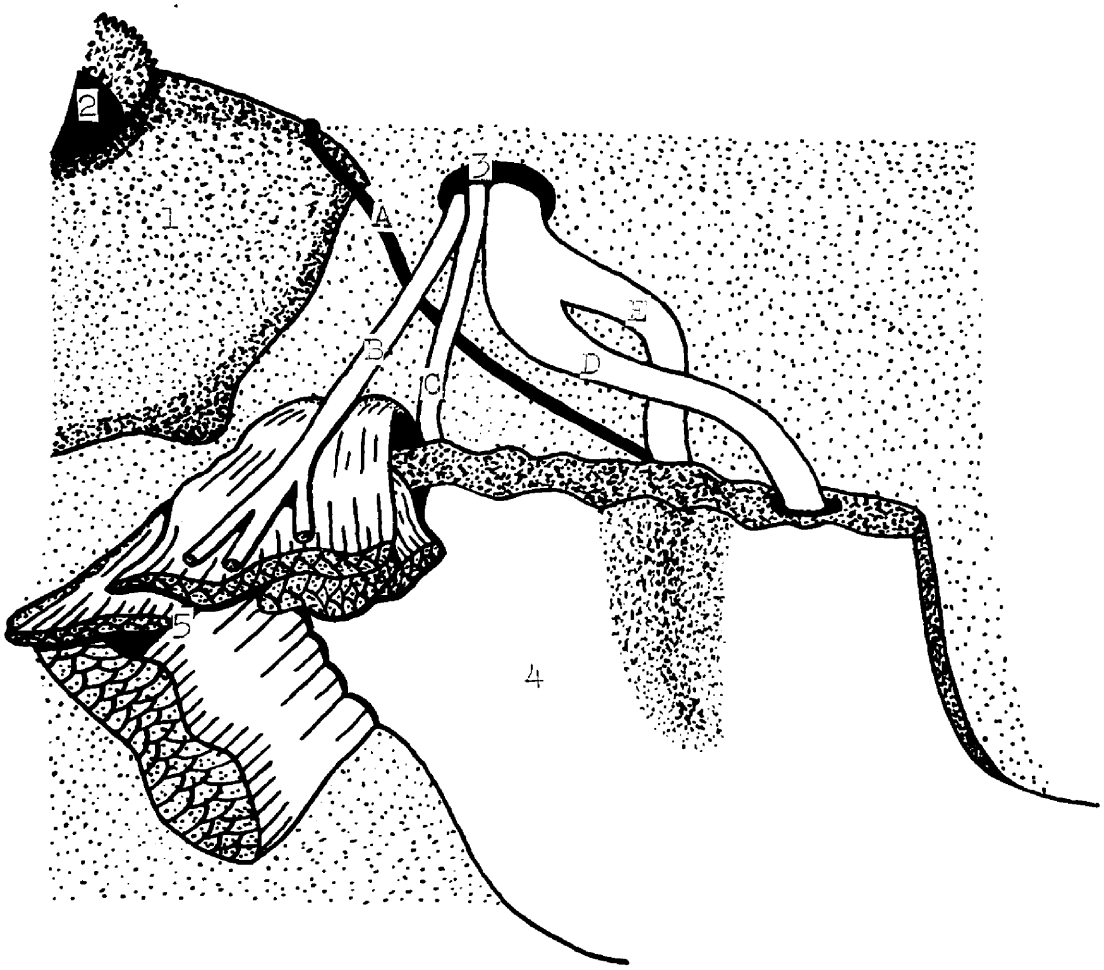
1. Auditory Bulla

2. External Auditory Meatus

3. Foramen Ovale

4. Mandible

5. Lateral Muscle Mass (reflected laterally)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(VENTROLATERAL VIEW, RIGHT SIDE)

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B. Auriculotemporal N.

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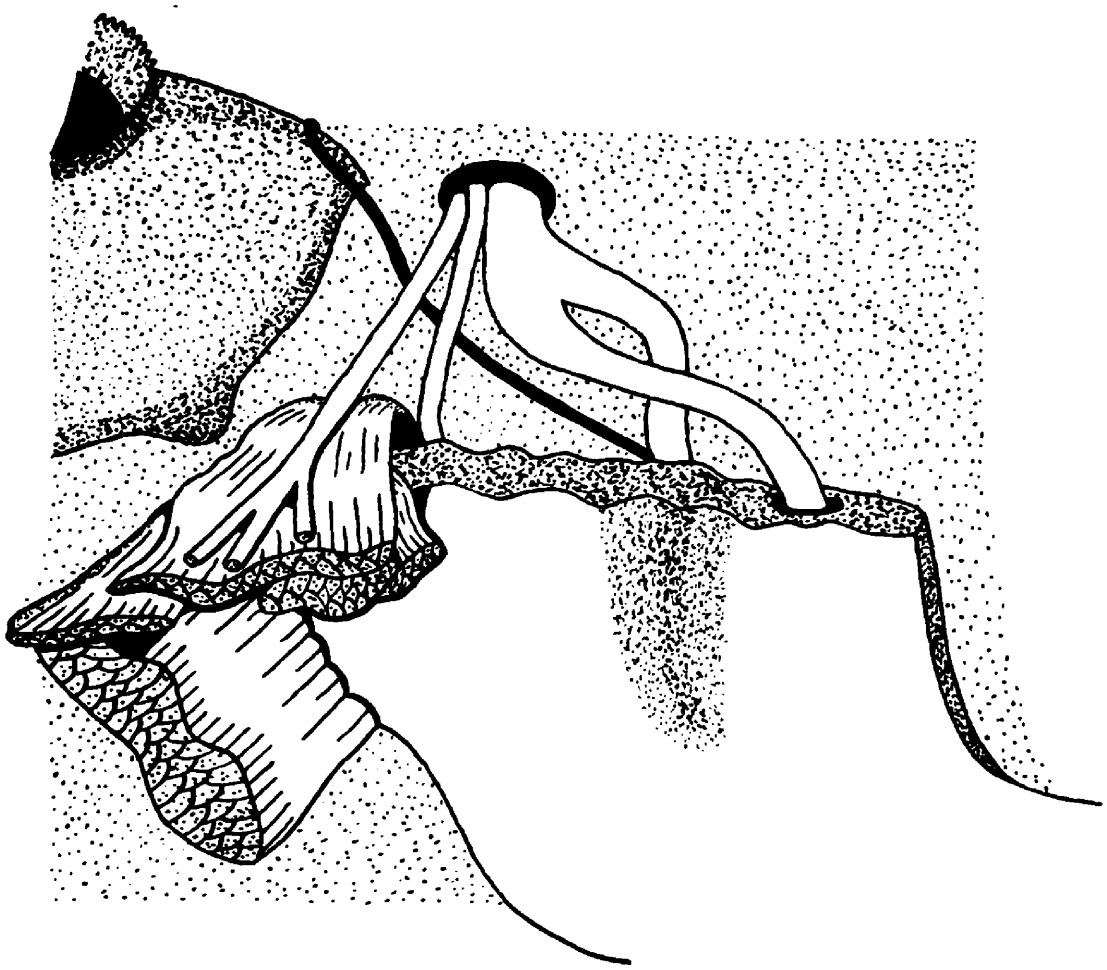
4. Mandible

5. Lateral Muscle Mass (reflected laterally)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b) The Lingual Nerve (E, fig. 6) is a large nerve which passes ventrally as the most cranial nerve of the posterior trunk. This nerve proceeds medially and parallel to the mylohyoid nerve as the former nerve passes toward the tongue. Shortly distad to its origin, the nerve receives the chorda tympani (A, fig. 6), a branch from the seventh cranial nerve. The lingual nerve continues beneath (medial to) the mylohyoid muscle, which separates it from the mylohyoid nerve (C, fig. 6). The lingual nerve proceeds into the submaxillary-sublingual gland complex where it bifurcates. Both rami loop laterally around the submandibular duct to pass dorsally through the glossal muscles. These rami enter the base of the tongue approximately five millimeters distad to the penetration of the hypoglossal nerve, and approximately one centimeter from where the duct enters the frenulum.

c) The Inferior Alveolar Nerve (D, fig. 6) is the largest nerve of the posterior trunk of the mandibular nerve. This nerve passes along the ramus of the mandible to enter the mandibular foramen. Within the mandibular canal the inferior alveolar nerve gives rise to numerous inferior dental nerves which pass to the molar teeth. Just proximal to the mental foramen the inferior alveolar nerve gives rise to incisor branches which pass to the incisor teeth of the mandible. The inferior alveolar nerve emerges from the mandibular canal through the mental foramen to give rise to several mental rami to the chin, lower lip, and mucosa of the lower jaw.

d) The Mylohyoid Nerve (C, fig. 6) passes ventrad along the ventral surface of the muscle of the same name, which separates this nerve from the lingual nerve. The mylohyoid nerve innervates the mm. mylohyoideus, transmandibularis and the anterior belly of the digastricus. The nerve then passes anteriorly to send rami to the skin of the inter-ramal space of the mandible.

B) The Anterior Trunk of the mandibular nerve leaves the cranium through the masticatory foramen, which is four millimeters rostral to the emergence of the posterior trunk and separated from the anterior lacerated foramen by a thin bony wall.

At the foramen the following branches are discernible:

a) Masseteric

b) Pterygoid

c) Buccinator

a) The Masseteric Nerve is the largest of the three main branches of the anterior trunk. This nerve passes in a dorsolaterad direction through the mandibular notch of the mandible directly into the masseter muscle where the nerve ramifies rather extensively.

b) The Pterygoid Nerves pass from the foramen in the middle position, ventrad to the large masseteric nerve and dorsad to the buccinator nerve. The pterygoid nerves are small nerves which pass directly to the pterygoid muscles.

c) The Buccinator Nerve emerges from the foramen as the most ventral division of the anterior trunk. This nerve is larger than the pterygoid nerves, but not quite as large as the masseteric nerve at its origin. The buccinator nerve usually passes rostrally for a few millimeters before proceeding ventrally beneath the temporal muscle and the anterior portion of the masseter muscle to reach the buccinator muscle.

VI. ABDUCENS NERVE

The Abducens Nerve (VI, fig. 1; A, fig. 2; B, fig. 3; A, fig. 4; B, fig. 5) arises from the posterior border of the pons or the anterior portion of the trapezium near the midline, anterior to the pyramidal tracts. This slender sixth cranial nerve passes rostrally through the anterior lacerated foramen along with the oculomotor, trochlear, and the ophthalmic and maxillary divisions of the trigeminal nerve. Within the orbit the nerve penetrates the lateral rectus muscle and sometimes the retractor oculi muscle.

VII. FACIAL NERVE

(Figs. 1, 7)

The Facial Nerve emerges from the rostral portion of the trapezium immediately anterior to the acoustic nerve and lateral to the abducens nerve. This seventh cranial nerve passes through the internal auditory meatus to enter the facial canal, which it follows through the petrous portion of the

temporal bone before leaving the cranium by way of the stylomastoid foramen.

The branches of the facial nerve may be grouped according to their points of origin from the facial nerve:

A. Within the Facial Canal

B. Within the Neck

C. Within the Parotid Gland

A. Within the Facial Canal:

At the entrance of the facial canal the seventh cranial nerve demonstrates a very small enlargement, the geniculate ganglion. Proceeding rostrally from this ganglion is a minute branch, the large superficial petrosal nerve. This small nerve passes forward through the pterygoid canal and continues in a cephalad direction to join the sphenopalatine ganglion, which is a small ganglion associated with the maxillary division of the trigeminal nerve as described by Mizeres (p. 3, 1950).

Within the facial canal the facial nerve also gives rise to the chorda tympani. This small nerve leaves the facial nerve to pass rostrally to come in close association with the ossicles of the tympanic cavity. It then continues rostrally to leave the anterior end of the auditory bulla and follows the lingual nerve, a branch of the mandibular portion of the trigeminal nerve (fig. 6).

B. Within the Neck:

Upon emergence from the skull through the stylomastoid

FIGURE 7. THE SUPERFICIAL BRANCHES OF THE FACIAL NERVE

A. Facial N.
B. Digastric N.
C. Stylohyoid N.
D. Posterior Auricular N.
E. Dorsal Division
F. Ventral Division
G. Temporal N.
H. Upper Zygomatic N.
I. Lower Zygomatic N.
J. Dorsal Buccal N.
K. Ventral Buccal N.

1. Portion of Parotid Gland
2. Trachea
3. Section of Parotid Duct

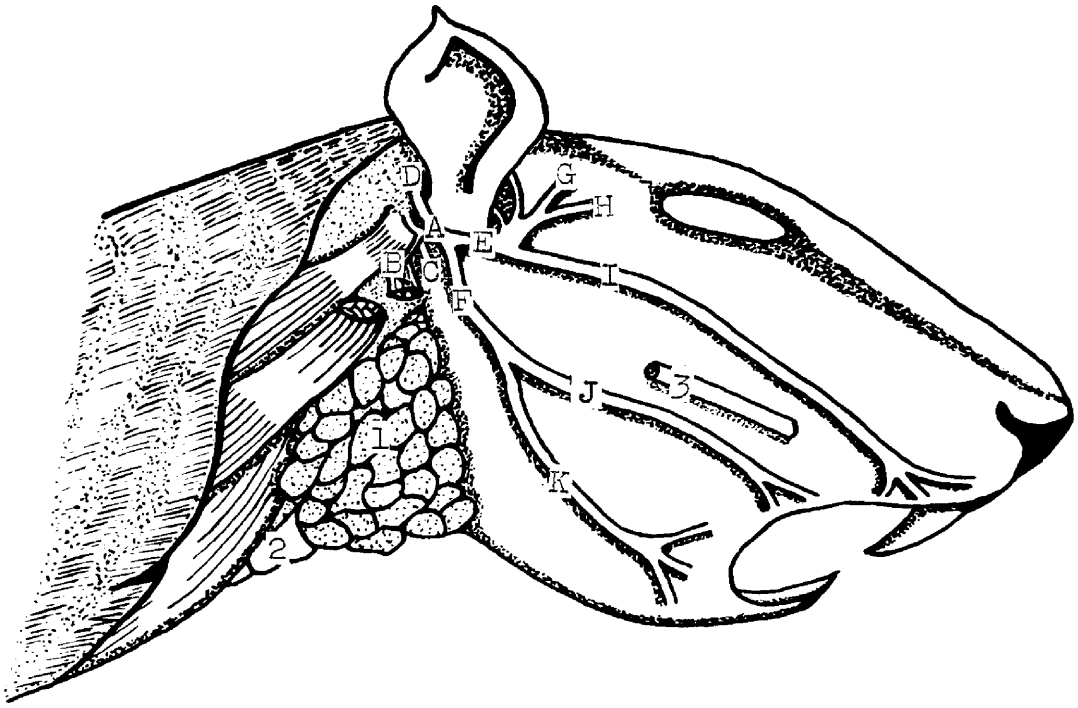

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FIGURE 7. THE SUPERFICIAL BRANCHES OF THE FACIAL NERVE

A. Facial N.
B. Digastric N.
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1. Portion of Parotid Gland
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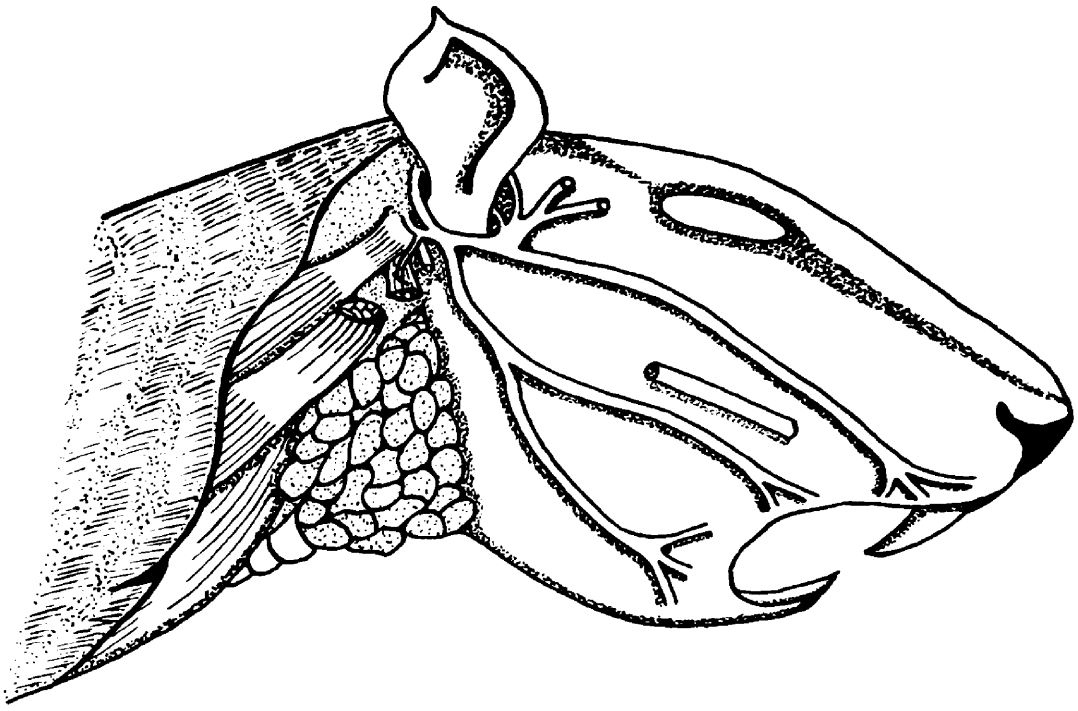

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foramen, the facial nerve appears on the lateral surface of the head at the base of the pinna as illustrated in figure 7.

Prior to its entrance into the parotid gland, the facial nerve gives rise to three branches:

a) Posterior Auricular

b) Digastric

c) Stylohyoid

a) The Posterior Auricular Nerve (D, fig. 7) leaves the facial nerve at the base of the pinna between the sternomastoid muscle and the cartilage of the ear caudal to the posterior auricular vessels. This nerve passes in a dorsocaudad direction to ramify on the posterior portion of the pinna.

b) The Digastric Nerve (B, fig. 7) shares a common origin from the facial nerve with the stylohyoid as shown in the figure. This nerve passes caudoventrad to innervate the posterior belly of the m. digastricus.

c) The Stylohyoid Nerve (C, fig. 7) arises from the common stem with the digastric nerve as described above. This nerve passes anteroventrad to innervate the stylohyoid muscle.

C. Within the Parotid Gland:

After giving rise to the above named branches, the facial nerve passes rostrad for approximately two millimeters to enter the parotid gland before bifurcating into the following:

I. Dorsal Division

II. Ventral Division

The distribution of the terminal rami of this facial nerve bifurcation in the fox squirrel is not exactly the same as that in the rat as described by Greene (p. 119, 1935); nor is it identical to the dichotomous branching of the facial nerve in the cat (Reighard and Jennings, p. 376, 1940).

I. Dorsal Division

As shown in figure 7, the Dorsal Division (E) gives rise to the following nerves:

1) Temporal

2) Upper Zygomatic

3) Lower Zygomatic

1) The Temporal Nerve (G, fig. 7) passes in a dorso-rostral direction to cross the caudal portion of the zygomatic arch. This nerve then distributes rami to the anterior auricular muscles, m. platysma, and the cranial border of the m. orbicularis oculi.

2) The Upper Zygomatic Nerve (H, fig. 7) usually arises from the dorsal division as a portion of a common stem with the temporal nerve. This nerve proceeds toward the lateral canthus of the eye to supply the m. orbicularis oculi and join terminal rami of the lacrimal branch of the trigeminal nerve.

3) The Lower Zygomatic Nerve (I, fig. 7) is the largest ramus of the dorsal division of the facial nerve. It traverses

distally over the masseter muscle between the eye and the parotid duct. This nerve distributes branches to the side of the nose before communicating with branches of the infra-orbital nerves of the trigeminal in the area of the upper lip.

II. Ventral Division

The Ventral Division (F, fig. 7) originates at the base of the pinna as shown in the figure. This division passes anteroventrad for approximately one centimeter before dividing into the following nerves:

1) Dorsal (Superior) Buccal

2) Ventral (Inferior) Buccal

1) The Dorsal (Superior) Buccal Nerve (J, fig. 7) passes rostrally, ventral and parallel to the parotid duct. Its terminal rami are distributed to the upper lip and communicate with the following: the lower zygomatic branches as described above, the infraorbital terminations of the trigeminal nerve, and the ventral buccal rami.

2) The Ventral (Inferior) Buccal Nerve (K, fig. 7) originates from the ventral division of the facial nerve to pass anteroventrad to the area of the lower lip where some of the terminal rami are in close association with the mental nerve ramification.

VIII. ACOUSTIC NERVE

The Acoustic Nerve (VIII, fig. 1) is attached to the brain at the lateral border of the trapezium caudal to the

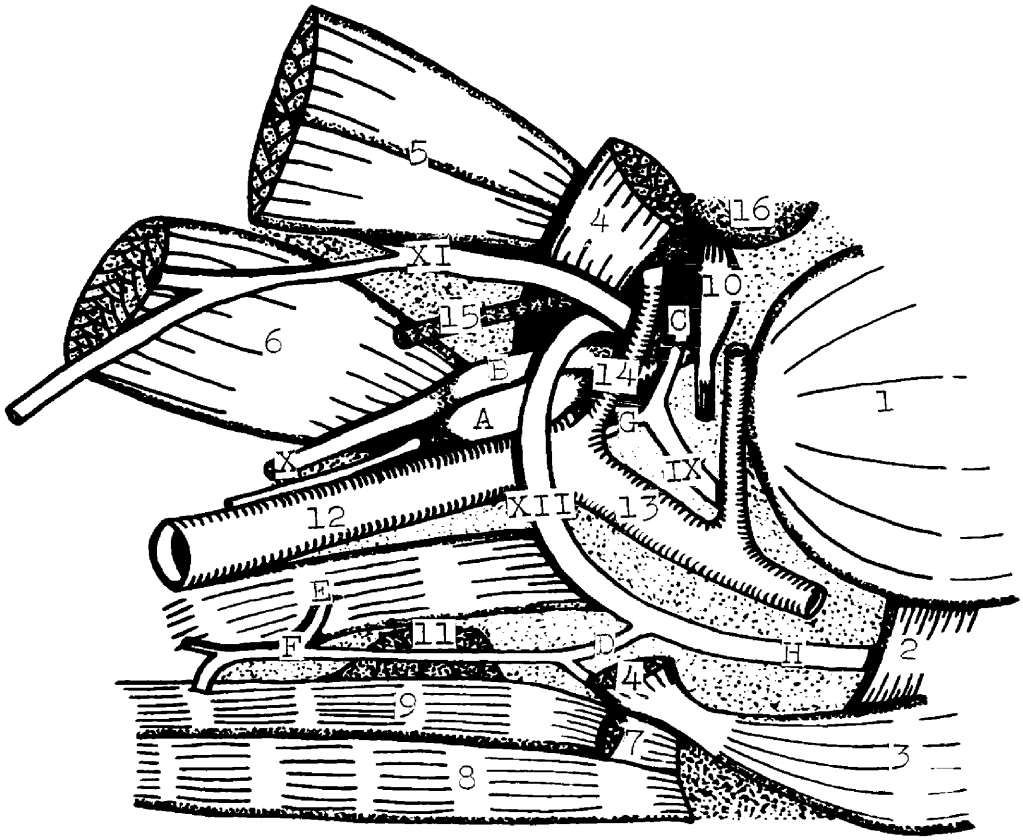
FIGURE 8. A SUPERFICIAL DISSECTION, SHOWING THE LAST FOUR CRANIAL NERVES EMERGING FROM THE CRANIUM

(VENTROMEDIAL VIEW, RIGHT SIDE)

A. Superior Cervical Ganglion
B. Nodose Ganglion
C. Petrosal Ganglion
D. Hypoglossal N. (descending ramus)
E. N. descendens cervicalis (cut)
F. Ansa Hypoglossi
G. Sino-carotid N.
H. Hypoglossal N. (ascending ramus)

IX. Glossopharyngeal N.
X. Vagus N.
XI. Spinal Accessory N.
XII. Hypoglossal N.

1. M. masseter
2. M. mylohyoideus
3. M. digastricus (anterior belly)
4. M. digastricus (posterior belly, cut)
5. Mm. sternomastoideus and cleidomastoideus (reflected dorsally)
6. M. omotransversarius
7. M. omohyoideus
8. M. sternohyoideus
9. M. sternothyroideus
10. M. stylohyoideus
11. Thyroid Gland
12. Common Carotid A.
13. External Carotid A.
14. Occipital A.
15. Internal Jugular V.
16. Base of Pinna



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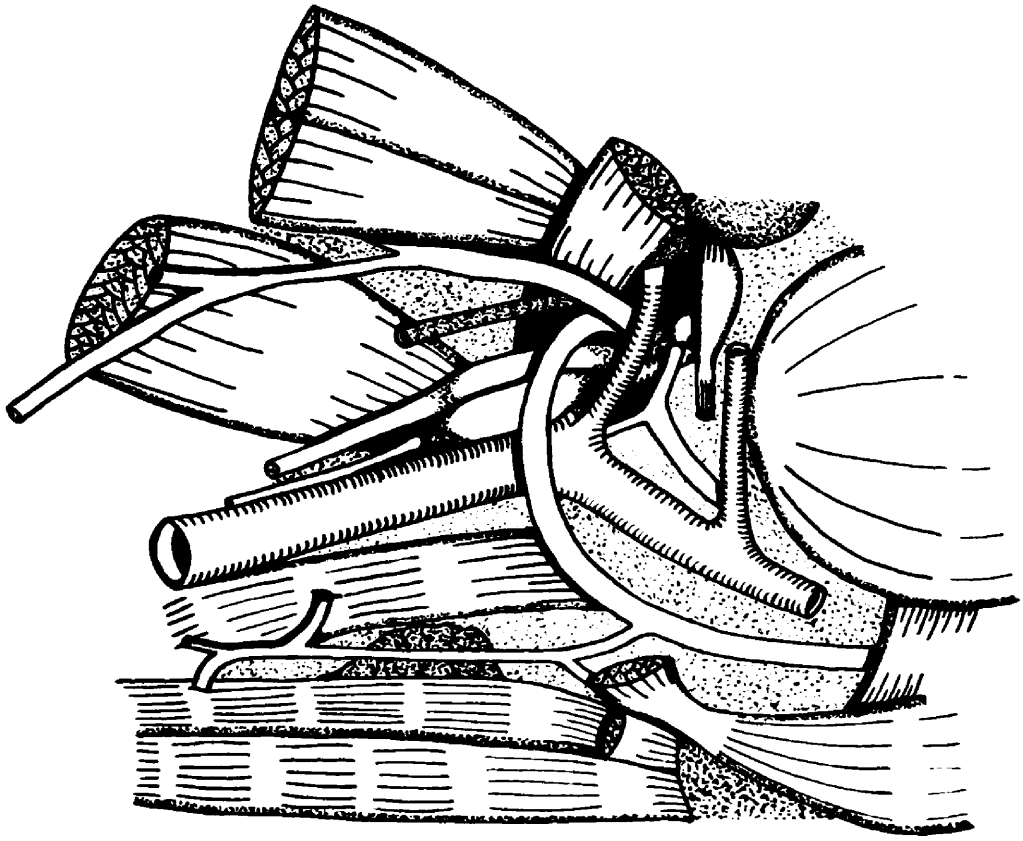
E. N. descendens cervicalis (cut)
F. Ansa Hypoglossi
G. Sino-carotid N.
H. Hypoglossal N. (ascending ramus)

IX. Glosso-laryngeal N.
X. Vagus N.
XI. Spinal Accessory N.
XII. Hypoglossal N.

1. M. masseter
2. M. mylohyoideus
3. M. digastricus (anterior belly)
4. M. digastricus (posterior belly, cut)
5. Mm. sternomastoideus and cleidomastoideus (reflected dorsally)
6. M. omotransversarius
7. M. omohyoideus
8. M. sternohyoideus
9. M. sternothyroideus
10. M. stylohyoideus
11. Thyroid Gland
12. Common Carotid A.
13. External Carotid A.
14. Occipital A.
15. Internal Jugular V.
16. Base of Pinna



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seventh and rostral to the ninth cranial nerves. The acoustic nerve consists of two main divisions: (a) the cochlear portion and (b) the vestibular portion. The cochlear division is found within the cochlea, and the vestibular division is associated with the semicircular canals. The origins of these divisions are determined only with much difficulty. Within the auditory bulla the two divisions unite to form a single trunk which proceeds into the medulla oblongata at the level of the trapezium in association with the neighboring cranial nerves as described above and shown in figure 1.

IX. GLOSSOPHARYNGEAL NERVE

(Figs. 1,8,9)

The Glossopharyngeal Nerve (IX, fig. 1) arises from the medulla oblongata of the brain, posterior to the acoustic nerve and rostral to the vagus nerve. Using the method of study employed in this work, it was not possible to demonstrate a separate superior ganglion which is described in references to this nerve in other common mammalian species such as man (McDonald and Chusid, p. 71, 1952) and cat (Reighard and Jennings, p. 378, 1940). Due to the fact that the ganglionated mass grossly observed in this ninth cranial nerve is largely outside the cranium, this enlargement is referred to as the petrosal ganglion. The final proof of the distribution of ganglionated cells within this area would require microscopic examination. Christensen, in his work

on the Rhesus monkey (p. 300, 1933), described ganglionated areas of the glossopharyngeal nerve in which cells of the superior and petrosal ganglia could be demonstrated microscopically.

As the glossopharyngeal nerve emerges from the cranium through the posterior lacerated foramen, it is in close association with the tenth, eleventh, and twelfth cranial nerves, cervical ganglionated trunk, internal jugular vein, and internal carotid artery as shown in figures 8 and 9. For the sake of clarity, the internal jugular vein has been omitted from figure 9.

At the emergence of the glossopharyngeal nerve from the cranium the petrosal ganglion is immediately dorsal to the internal carotid artery and anteroventromediad to the nodose ganglion of the vagus nerve. The nerve passes ventromediocaudad to cross the internal carotid artery. One millimeter distad to the ganglion the glossopharyngeal nerve meets the pharyngeal branch of the vagus nerve (B, fig. 9). These nerves are bound together only by areolar connective tissue and therefore are easily separated. This pharyngeal contribution from the tenth cranial nerve crosses between the superior ganglion of the cervical ganglionated trunk and the glossopharyngeal nerve; ventrolaterad to the former and dorsomediad to the latter. This branch of the vagus passes ventromediad parallel to the glossopharyngeal nerve to innervate the epiglottic region and contribute to the pharyngeal plexus.

Two millimeters from the caudal end of the petrosal ganglion, the glossopharyngeal nerve gives rise to the sino-carotid nerve (G, fig. 8). This nerve passes directly to the carotid body and carotid sinus within the fork of the bifurcation of the common carotid artery to form the internal and external carotid arteries.

After giving off this nerve, the glossopharyngeal nerve continues ventrad under cover of the hyoid and muscles attaching to it. The glossopharyngeal nerve tends to run a short course parallel and dorsal to the hypoglossal nerve, separated from it by muscles attaching to the hyoid. Approximately five millimeters beyond the sino-carotid origin, the glossopharyngeal nerve ramifies to send some small branches caudad to contribute to the pharyngeal plexus; other branches enter the caudal portion of the base of the tongue.

X. VAGUS NERVE

(Figs. 1,8,9)

The Vagus Nerve arises from the medulla between the origins of the glossopharyngeal and the spinal accessory nerves as shown in figure 1. The vagus nerve emerges from the cranium through the posterior lacerated foramen in very close association with cranial nerves nine, eleven, and twelve, and the superior cervical ganglion and blood vessels as illustrated in figures 8 and 9. As these nerves lie within the foramen, cranial nerves ten and eleven are bound together so tightly that it is almost impossible to separate

FIGURE 9. THE LEFT AUDITORY BULLA, SHOWING THE EXIT OF THE LAST FOUR CRANIAL NERVES FROM THE CRANIUM

(VENTROLATERAL VIEW)

A. Cervical Ganglionated Trunk (Cord)

B. Pharyngeal Branch from X to IX

C. Superior Laryngeal N.

D. Nodose Ganglion

E. Superior Cervical Ganglion

F. Petrosal Ganglion

IX. Glossopharyngeal N.

X. Vagus N.

XI. Spinal Accessory N.

XII. Hypoglossal N.

1. Auditory Bulla

2. Common Carotid A.

3. External Carotid A.

4. Posterior Lacerated Foramen

5. Hypoglossal Foramen

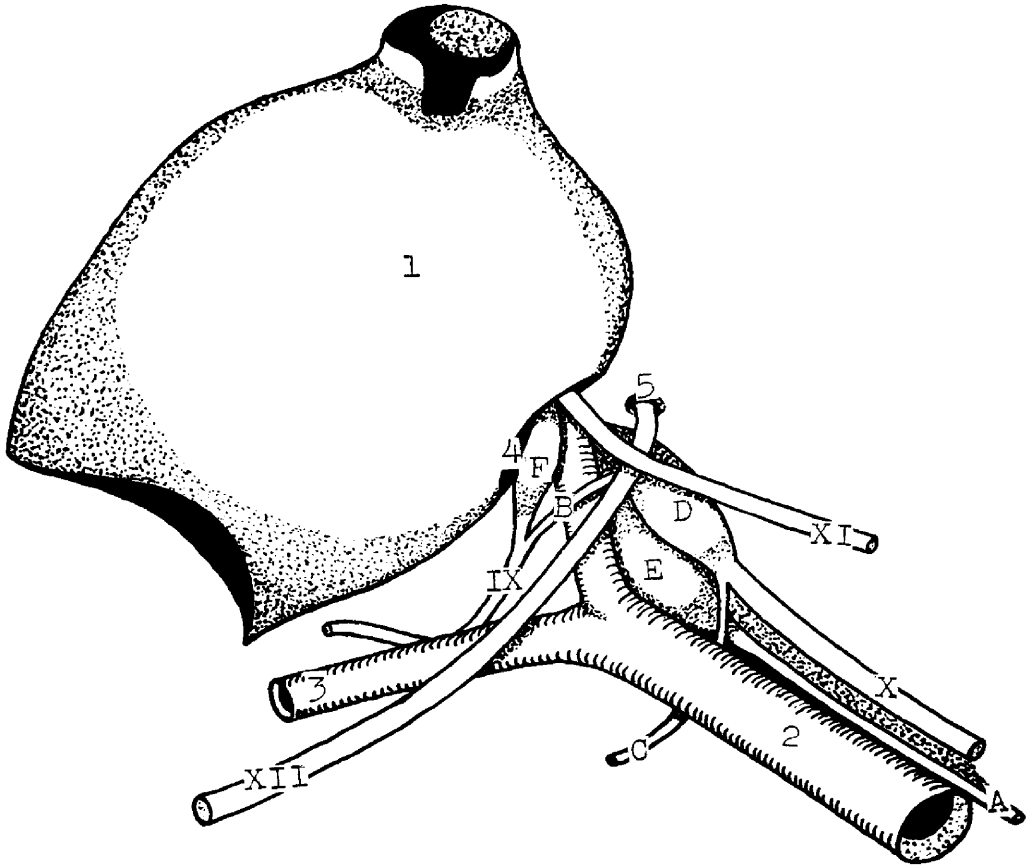

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FIGURE 9. THE LEFT AUDITORY BULLA, SHOWING THE EXIT OF THE LAST FOUR CRANIAL NERVES FROM THE CRANIUM

(VENTROLATERAL VIEW)

A. Cervical Ganglionated Trunk (Cord)

B. Pharyngeal Branch from X to IX

C. Superior Laryngeal N.

D. Nodose Ganglion

E. Superior Cervical Ganglion

F. Petrosal Ganglion

IX. Glossopharyngeal N.

X. Vagus N.

XI. Spinal Accessory N.

XII. Hypoglossal N.

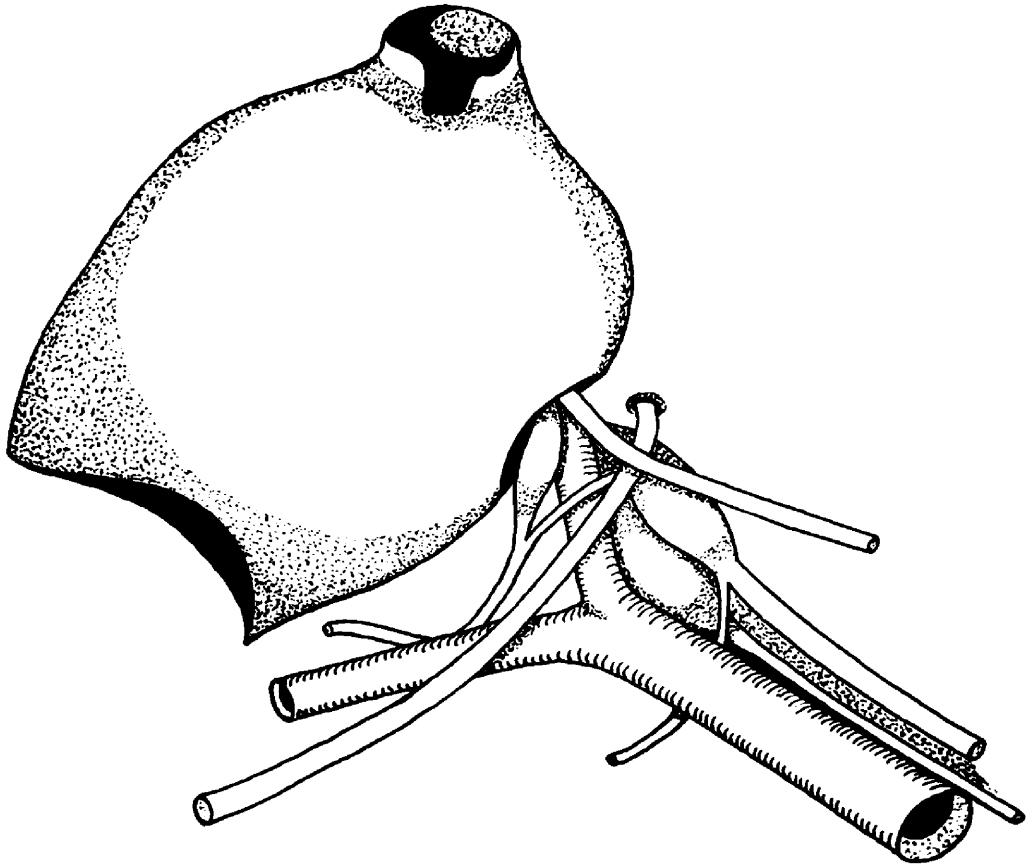
1. Auditory Bulla

2. Common Carotid A.

3. External Carotid A.

4. Posterior Lacerated Foramen

5. Hypoglossal Foramen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them completely, even under the dissecting microscope. In the human these two cranial nerves occupy the same sheath of dura mater while within the foramen (Durward, p. 1038, 1951). The closeness of these two nerves in this location suggests such an arrangement in the fox squirrel. No jugular (superior) ganglion of the vagus was discernible in the fox squirrel as described in references to common mammalian species such as man (Durward, 1038, 1951), dog (Ellenberger and Baum, p. 526, 1891), and cat (Reighard and Jennings, p. 378, 1940). The vagus nerve is one of the two cranial nerves which leave the cranial or cervical regions of the body; therefore the nerve may be discussed according to the areas of the body through which it traverses:

I) Cervical Portion

II) Thoracic and Abdominal Portion

The consideration of the vagal rami as they participate in various autonomic plexuses is beyond the scope of this work. For such details as are applicable to the fox squirrel, reference should be made to the work of Mizeres (pp. 25-30, 1950).

I. The Cervical Portion of the Vagus Nerve:

Shortly beyond the emergence of the vagus nerve from the cranium there is an enlargement, the nodose ganglion (B, fig. 8; D, fig. 9). This ganglion is smaller than the superior cervical ganglion of the cervical ganglionated trunk which is located medial to the vagal ganglion. There

are two branches which arise from the nodose ganglion; (a) the pharyngeal branch (B, fig. 9) which passes mediad from the cranial end of the ganglion over the pterygopalatine artery to join the glossopharyngeal nerve as shown in the figure; (b) the superior laryngeal nerve (C, fig. 9) which passes mediad from the caudal end of the ganglion ventral to the caudal end of the superior cervical ganglion and dorsal to the common carotid artery to reach the larynx and thyroid gland.

The vagus nerve is larger in diameter than the cervical ganglionated trunk and traverses caudally within the carotid sheath in close association with, but completely separate from, the cervical ganglionated trunk, common carotid artery, and internal jugular vein. This relationship persists to a level just cephalad of the thoracic inlet.

II. The Thoracic and Abdominal Portions of the Vagus Nerve:

Due to the differences in the courses and relationships of the right and left vagi, each vagus nerve is considered separately. The reader is referred to Mizeres (plate VIII, 1950) for an illustration of the vagi nerves in the fox squirrel.

A. The Right Vagus Nerve

At the level of the subclavian artery the right vagus nerve gives rise to the right recurrent laryngeal nerve. This recurrent nerve loops around the subclavian artery to reach the right lateral surface of the trachea, which it

follows craniad to penetrate the larynx. At the origin of the recurrent nerve, the vagus lies dorsal to the phrenic nerve and ventral to the subclavian artery. At this same location rami are given off from the vagus to the middle cervical ganglion and to the cardiac plexus. After giving rise to the recurrent nerve as described, the right vagus continues caudad onto the ventral side of the trachea for a very short distance before passing dorsad to follow the lateral side of the trachea and pass dorsal to the root of the lung. At the level of the lung root, rami are supplied to the pulmonary plexus. The right vagus nerve continues caudodorsad to follow the right side of the esophagus and supplies rami which anastomose with the left vagus to form the esophageal plexus. The right vagus then deviates toward the dorsal side of the esophagus as it passes through the esophageal hiatus of the diaphragm. Within the abdomen the right vagus usually tends to remain dorsad as it reaches the cardiac stomach where rami anastomose with the left to form a gastric plexus. The nerve is easily lost to view as it enters the celiac plexus.

B. The Left Vagus Nerve

At the level of the first rib the left vagus nerve enters the thorax and passes caudad to cross ventral to the left subclavian artery and dorsal to the left anterior vena cava. As the left vagus crosses the origin of the left subclavian artery (at the aortic arch in the fox squirrel) the

nerve gives rise to the left recurrent laryngeal nerve which loops around the ligamentum arteriosum. The recurrent nerve ascends toward the left side of the trachea and contributes rami to the cardiac plexus before continuing craniad along the lateral side of the trachea to terminate within the larynx as the inferior laryngeal nerve. In the same general area as the origin of the recurrent laryngeal nerve, the left vagus nerve supplies rami to the cardiac and pulmonary plexuses. The vagus then continues dorsocaudad to pass dorsal to the root of the lung to reach the esophagus where it supplies rami which anastomose with the right vagus to form the esophageal plexus. The left vagus tends to remain on the ventral side of the esophagus as it passes through the esophageal hiatus of the diaphragm. Within the abdomen the left vagus usually tends to remain ventral along the lesser curvature of the stomach where some rami anastomose with the right vagus to form a gastric plexus. Additional rami are difficult to positively define as they become involved within the autonomic plexuses.

XI. SPINAL ACCESSORY NERVE

(Figs. 1,8,9)

The Spinal Accessory Nerve arises from the lateral surface of the medulla oblongata and spinal cord as shown in figure 1. The numerous spinal rootlets give rise to the portion of this eleventh cranial nerve which passes cranially,

FIGURE 10. THE RIGHT ANSA HYPOGLOSSI (VENTRAL VIEW)

A. Hypoglossal N. (ascending ramus)
B. Hypoglossal N. (descending ramus)
C. N. descendens cervicalis
D. Ansa Hypoglossi

1. M. masseter
2. M. digastricus (anterior belly)
3. M. digastricus (posterior belly)
4. M. mylohoideus
5. M. omohyoideus
6. M. sternohyoideus
7. M. sternothyroideus
8. M. longus colli
9. M. sternomastoideus (pulled laterally)
10. Mm. pectorales
11. Trachea
12. Thyroid Gland

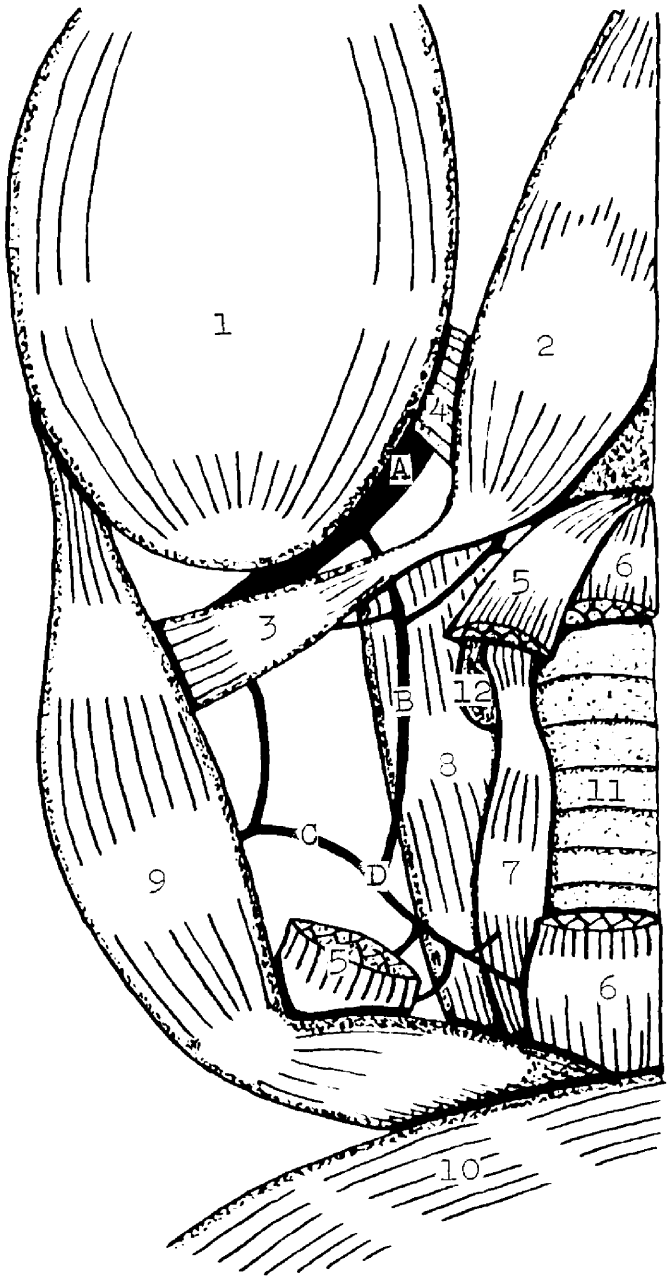

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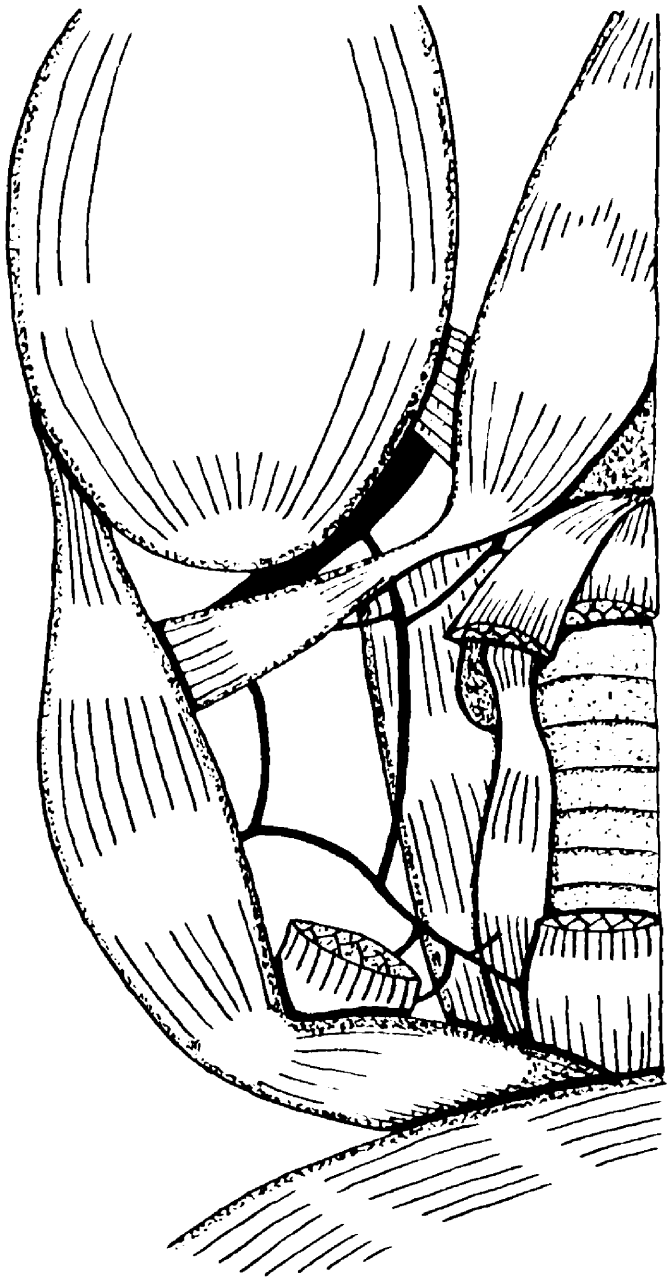
FIGURE 10. THE RIGHT ANSA HYPOGLOSSI (VENTRAL VIEW)

A. Hypoglossal N. (ascending ramus)
B. Hypoglossal N. (descending ramus)
C. N. descendens cervi alis
D. Ansa Hypoglossi

1. M. masseter
2. M. digastricus (anterior belly)
3. M. digastricus (posterior belly)
4. M. mylonoideus
5. M. omohyoideus
6. M. sternohyoideus
7. M. sternothyroideus
8. M. longus colli
9. M. sternomastoideus (pulled laterally)
10. Mm. pectorales
11. Trachea
12. Thyroid Gland



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through the foramen magnum closely adjacent to the spinal cord to meet the portion of the nerve which arises from the medulla oblongata of the brain.

The spinal accessory nerve leaves the skull through the posterior lacerated (petrobasilar) fissure in very close association with the glossopharyngeal, vagus and hypoglossal nerves. As this nerve emerges from the cranium it is also related to the superior cervical ganglion, the internal carotid and occipital arteries, and the internal jugular vein. The spinal accessory nerve proceeds caudad in a dorsolateral plane with respect to the associated structures named above. The nerve bifurcates to give rise to one branch which innervates the m. sternomastoideus; the other ramus proceeds dorsocaudad to cross over the m. omotransversarius and anastomose with communicating branches usually from the third and fourth cervical nerves. This anastomosis forms the subtrapezial plexus which gives rise to several inconsistent branches which innervate the trapezius muscles.

XII. HYPOGLOSSAL NERVE

(Figs. 1,8,9,10)

The Hypoglossal Nerve arises from the caudal portion of the medulla oblongata by rootlets as illustrated in figure 1.

This last cranial nerve emerges from the cranium through the hypoglossal canal, which is located almost midway between the posterior lacerated foramen and the rostral edge of the occipital condyle on the ventral surface of the cranium. As

the hypoglossal nerve emerges from the hypoglossal canal, it passes ventromedial to the spinal accessory nerve and dorsolateral to the vagus nerve and associated structures passing through the posterior lacerated foramen as shown in figures 8 and 9.

This nerve proceeds in a ventromediad direction to cross the bifurcation of the common carotid artery as shown in figure 8. Approximately five or six millimeters beyond the common carotid artery the nerve bifurcates into the following:

A. Descending Ramus

B. Ascending Ramus

A) The Descending Ramus of the Hypoglossal Nerve (D, fig. 8; B, fig. 10) arises from the twelfth cranial nerve in the manner stated above and as shown in the figures. In the fox squirrel this ramus is much less than one millimeter in diameter. This thin ramus proceeds caudad ventral to the m. rectus capitus and laterad to the m. sternothyroideus. Beyond the level of the thyroid gland this thin nerve receives the n. descendens cervicalis from the first three or four cervical nerves to form the ansa hypoglossi (F, fig. 8; D, fig. 10) from which small branches are distributed to the mm. sternohyoideus, thyrohyoideus, and omohyoideus as shown in figure 10. Close to its origin, proximad to the ansa hypoglossi, the descending ramus gives rise to a small branch which innervates the posterior belly of the m. digastricus.

B) The Ascending Ramus of the Hypoglossal Nerve (H, fig. 8; A, fig. 10) is much larger than the descending ramus, being almost equally as large as the hypoglossal nerve prior to the bifurcation to form its rami. The ascending ramus continues rostrally to penetrate the m. mylohyoideus where the nerve is ventral to the lingual artery and dorsal to the submaxillary duct. This nerve enters the tongue five millimeters caudad to the penetration into the tongue by the lingual nerve, a branch of the mandibular division of the trigeminal nerve. The ascending ramus of the hypoglossal nerve supplies branches to both the extrinsic and intrinsic muscles of the tongue.

IV. THE SPINAL NERVES

The paired spinal nerves in the fox squirrel are similar in construction and arrangement to the spinal nerves found in most mammals. These nerves arise in segmental order from the spinal cord and emerge from the vertebral canal by passing through the intervertebral foramina. The details of the peripheral distribution of the individual nerves are given below. There are usually thirty-six or thirty-seven pairs of spinal nerves as follows: eight cervical, thirteen thoracic, six lumbar, three sacral, and a variable number of coccygeal nerves, but usually six or seven. The number of nerves agrees with the number of vertebrae in the thoracic, lumbar, and sacral regions. In the cervical region there is one more pair of nerves than there are vertebrae, viz., there are seven cervical vertebrae and eight cervical nerves. In the caudal (coccygeal) region there are far fewer nerves than there are vertebrae. In the cervical region, caudal to the atlas, the nerve emerges cranial to its respective vertebra; but in other regions the nerve emerges caudal to its respective vertebra. In the cervical, brachial, and lumbosacral regions typical plexuses are formed by the ventral primary divisions of the nerves.

The terminology of the components of a typical spinal nerve is not uniform. Different authorities apparently do not attempt to conform to one standard terminology with regard to this particular point. Ranson (p. 23, 1953),

Ellenberger and Baum (p. 537, 1891), and Durward (p. 1050, 1951) refer to the products of the first bifurcation of the spinal nerve as "rami"; whereas McDonald and Chusid (p. 78, 1952) and in some places Greene (p. 121, 1935) use the terminology similar to that given below, viz., the first bifurcation of the spinal nerve results in dorsal and ventral "divisions". Toldt (p. 810, 1948) gives both sets of terminology; and as indicated above, Greene uses different terminology in different places. In this work, the author uses the terminology because of the ease of positively distinguishing by definition the differences among roots, divisions, and rami (branches) as components of the typical spinal nerve (cf. fig. 14).

The connections of a spinal nerve with the spinal cord are by means of the dorsal and ventral roots (B and C, fig. 14). Within the intervertebral foramen the dorsal and ventral roots unite to form the trunk of the spinal nerve or spinal nerve proper (E). Immediately prior to this union, while still within the vertebral column, the dorsal root displays an enlargement, the dorsal root ganglion or spinal ganglion. This ganglion is small (approximately one millimeter in length), but prominent when observed through the dissecting microscope. Immediately distal to the point of union of the dorsal and ventral roots to form the spinal nerve there is a dichotomous branching into the following:

A. Dorsal Primary Division

B. Ventral Primary Division

A. The Dorsal Primary Division:

The dorsal primary division (F, fig. 14) is smaller than the ventral division. This division passes dorsad to supply the epaxial muscles and integument. This primary division gives rise to medial branches (rami) (4) which innervate the dorsal area adjacent to the vertebral column, and to lateral branches (rami) (K) which innervate the epaxial muscle mass and integument lateral to the former.

B. The Ventral Primary Division:

The ventral primary division (G) is much larger than the dorsal division. As stated previously, this division contributes to typical plexuses in the cervical, brachial, and lumbo-sacral regions. Figure 14 illustrates the characteristics of the ventral division of the spinal nerve in the thoracic region. This region demonstrates best the stereotyped construction of the ventral division of the spinal nerve. The details of this construction are discussed under the thoracic nerves. Because of the modifications of the ventral division in other regions of the body, the construction as given for the thoracic nerve is not so demonstrable.

FIGURE 11. THE RIGHT CERVICAL PLEXUS

A. First Cervical N.

B. Second Cervical N.

C. Third Cervical N.

D. Fourth Cervical N.

E. Fifth Cervical N.

F. Phrenic N.

G. C-4 Origin of Phrenic N.

H. Hypoglossal N. (descending ramus)

I. N. descendens cervicalis

J. Ansa Hypoglossi

K. Cervical Ganglionated Trunk (cord)

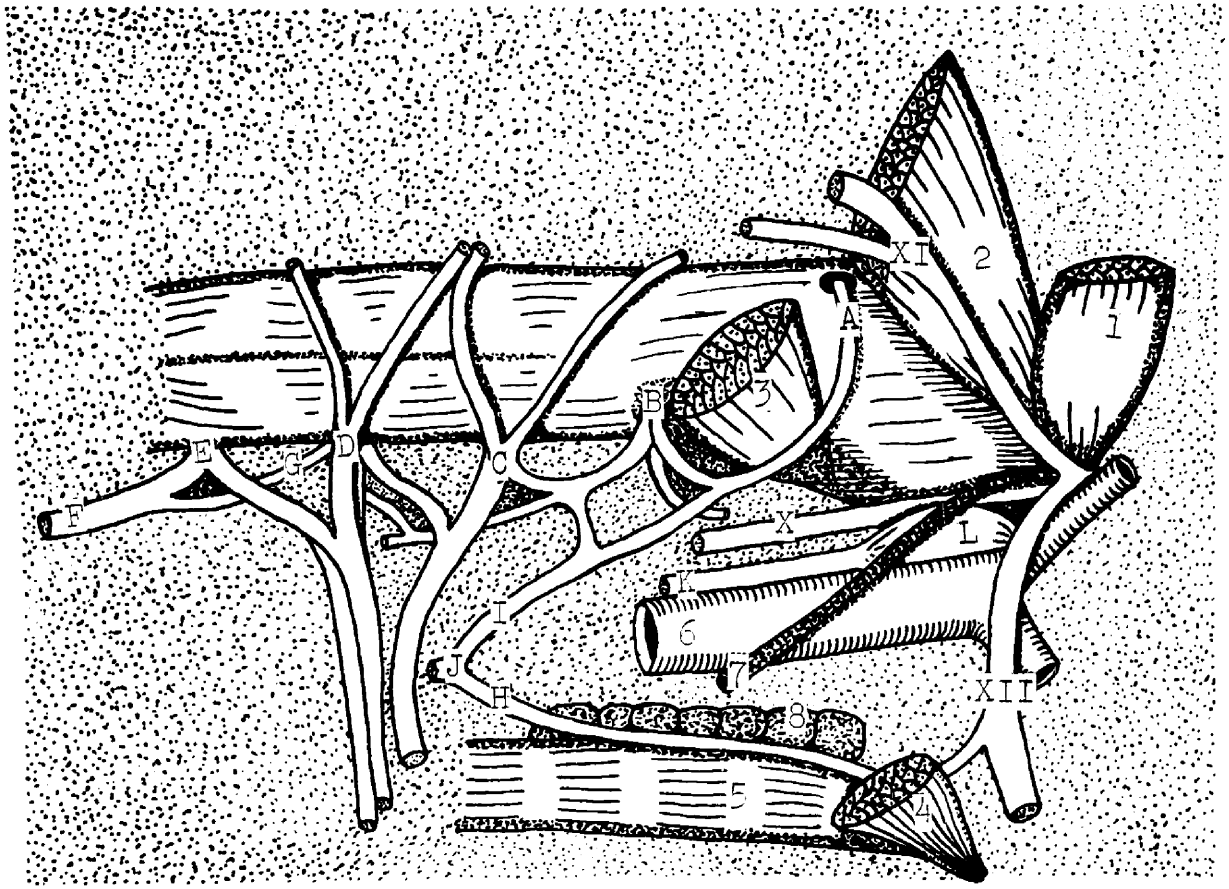
L. Superior Cervical Ganglion

X. Vagus N.

XI. Spinal Accessory N.

XII. Hypoglossal N.

1. M. digastricus (posterior belly, reflected dorsally)
2. M. sternomastoideus
3. M. omotransversarius
4. M. omohyoideus
5. M. sternothyroideus
6. Common Carotid A.
7. Internal Jugular V.
8. Thyroid Gland



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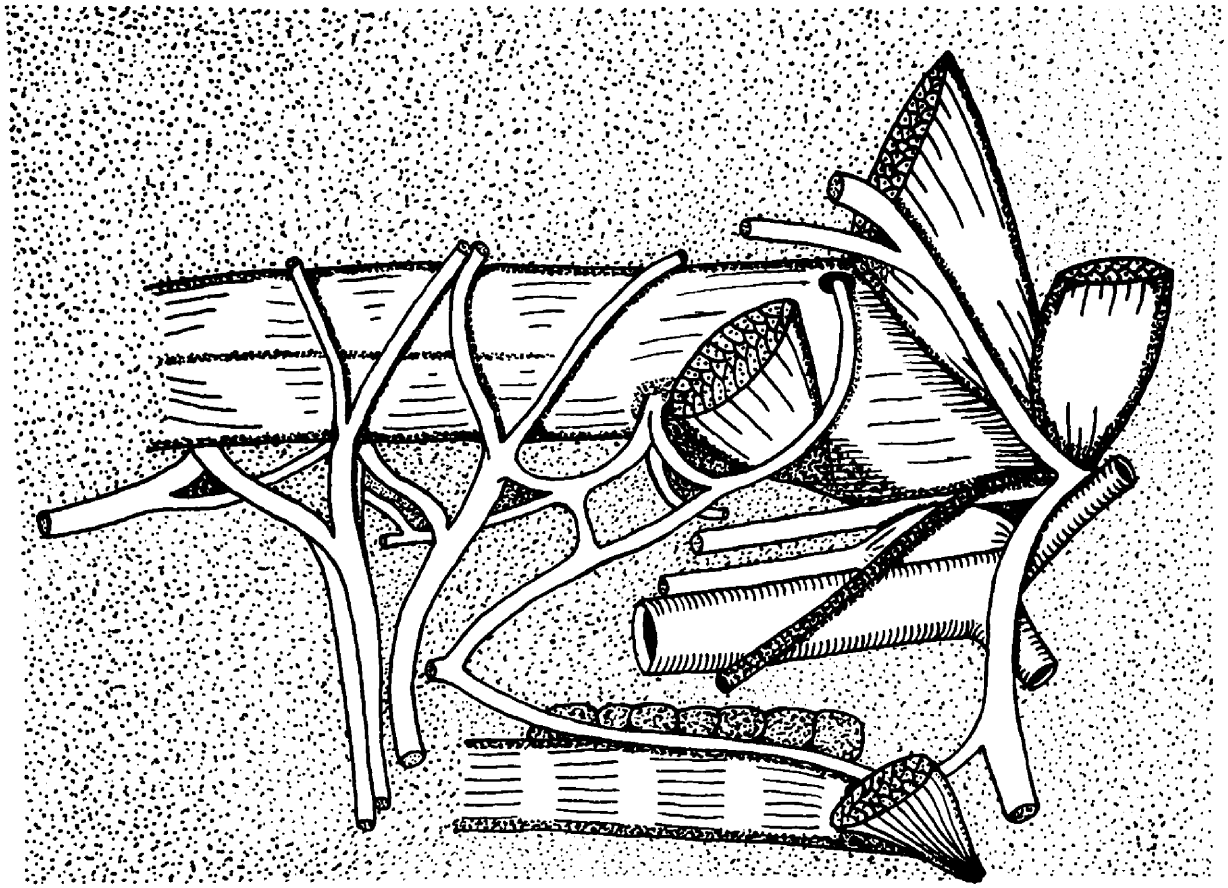
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A. THE CERVICAL PLEXUS

(Fig. 11)

The Cervical Plexus is composed primarily of the ventral divisions of the first four cervical nerves. The fifth cervical nerve contributes to both the cervical and brachial plexuses in addition to contributing to the origin of the phrenic nerve. There is an intimate arching communication of adjacent nerves comprising the cervical plexus as illustrated in figure 11.

Each nerve of the plexus may be divided into a dorsal and a ventral division in typical spinal nerve fashion. The dorsal divisions are smaller, with the exception of the second cervical nerve, and pass dorsad to innervate the epaxial muscle mass and integument of the dorsal cervical region. The second cervical nerve is peculiar with regard to the following two factors: (a) the dorsal division of this nerve is larger than the ventral division; (b) sometimes the ganglion of this nerve is located outside the vertebral column, hidden from ventral view by the transverse process of the axis. The ventral divisions of the first four, and part of the fifth, cervical nerves form the true cervical plexus, and may be described individually for the fox squirrel as follows:

The division of the first cervical nerve (A, fig. 11) which contributes to the cervical plexus emerges from the intervertebral (atlantal) foramen of the atlas to pass under

the wing of the atlas, around the origin of the m. omotransversarius (m. levator scapular ventralis) before giving rise to a ramus which passes to the second cervical nerve. The first cervical nerve continues caudad to form the main stem of the n. descendens cervicalis (I, fig. 11) which joins the descending ramus of the hypoglossal nerve to form the ansa hypoglossi (D, fig. 10; F, fig. 8; 4, fig. 11). The first four cervical nerves contribute to the formation of the n. descendens cervicalis as illustrated in figure 11.

The ventral division of the second cervical nerve (B, fig. 11) passes between the arches of the atlas and the axis to give rise to a loop which passes caudad to join the third cervical nerve. Shortly after its emergence from the vertebral column, the second cervical nerve gives rise to a very small muscular ramus which passes craniolaterad, deep to the first cervical nerve, to nearby deep muscles of the neck. From this second cervical nerve there is also a muscular branch which passes caudad to receive connecting rami from the third and fourth cervical levels. By means of this muscular ramus these cervical nerves usually contribute to the n. descendens cervicalis by at least one connecting ramus as illustrated in figure 11.

The peripheral branches of the third and fourth cervical nerves (C and D, fig. 11) are longer than those of the first two cervical nerves. Some of the peripheral nerves from the third and fourth levels tend to approach each other

and proceed distally in a rather intimate relationship as illustrated in the figure.

There are three general groups of rami arising from the third and fourth cervical nerves which are rather inconsistent in their exact points of origin and exact courses. Without attempting to consider the details of the individual variations of these rami, the three groups may be described in general terms as follows:

1) There are rami arising from both the third and fourth cervical nerves which pass dorsad under the m. omotransversarius to meet terminal rami of the spinal accessory nerve to form a network beneath the trapezial muscles, the subtrapezial plexus, from which nerves are distributed to muscles of the lateral and dorsal sides of the neck.

2) There are other rami, the supraclavicular nerves, which arise from the third and fourth cervical nerves to pass lateroventrad over the sternomastoideus muscles, through the parotid gland, to terminate as cutaneous branches on the ventral side of the shoulder and chest.

3) Lastly, there are rami from the third and fourth levels which pass craniolaterad to ramify within the parotid gland before emerging to supply the skin and m. platysma in the area of the cheek and upper neck.

In the fox squirrel the fifth cervical nerve (E, fig. 11) plays a minor role with regard to its contribution to the cervical plexus. This nerve merely sends one large

ramus rostrally to join the fourth cervical nerve as shown in the figure. This nerve also contributes in a minor way to the brachial plexus as described later.

In this species the fifth cervical nerve plays a major role in the formation of the phrenic nerve (F, fig. 11). Usually the phrenic nerve arises mainly from the fifth cervical nerve, with a minor contribution from the fourth cervical nerve (G, fig. 11). Sometimes the sixth cervical nerve contributes a small ramus to the phrenic nerve. The phrenic nerve passes caudad, ventral to the emergence from the vertebral column of the nerves contributing to the brachial plexus. Due to the differences in the origins and relationships of the right and left subclavian arteries in the fox squirrel (Jenkins, p. 12, 1950), each phrenic nerve is considered separately.

(a) The Right Phrenic Nerve enters the thorax and ventrally crosses the vagus and origin of the recurrent laryngeal nerve at the subclavian artery. The right phrenic nerve then follows the anterior vena cava caudad to the heart to continue over the right atrial wall before passing to the root of the right lung. Caudal to the heart the phrenic nerve follows the ventral surface of the posterior vena cava to terminate in the diaphragm.

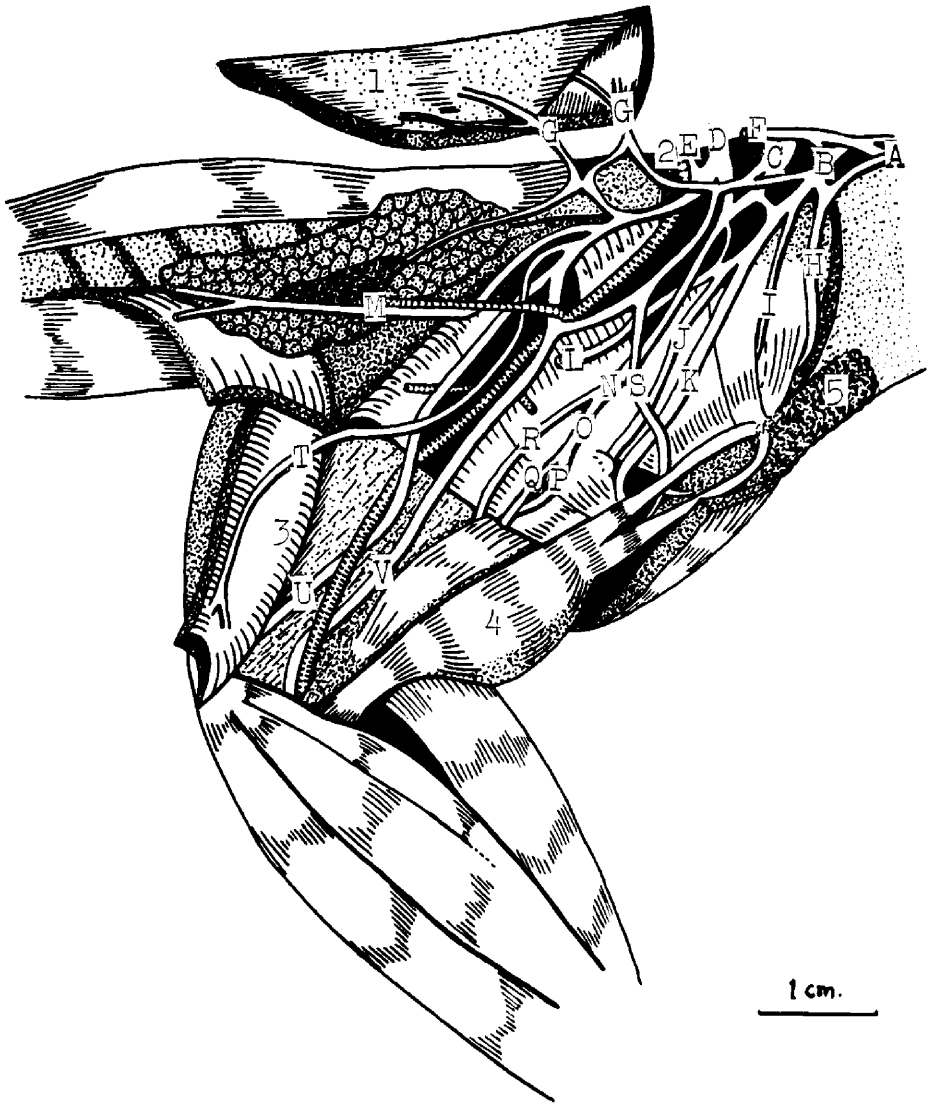
(b) The Left Phrenic Nerve has a course similar to the right phrenic nerve as far caudad as the thoracic inlet. Within the thorax the left phrenic nerve follows the left

anterior vena cava, being in this case medial to the left subclavian artery. As the phrenic nerve approaches the level of the root of the lung, the left anterior vena cava is between the phrenic and the root of the lung. As the nerve continues caudad, it leaves the surface of the heart to pass between the lobes of the lung and finally reach the diaphragm, which it innervates.

FIGURE 12. THE LEFT BRACHIAL PLEXUS

A. Fifth Cervical N. (Ventral Div.)
B. Sixth Cervical N.
C. Seventh Cervical N.
D. Eighth Cervical N.
E. First Thoracic N.
F. Phrenic N.
G. Anterior Thoracic (Pectoral) N.
H. Suprascapular N.
I. Cranial Subscapular N.
J. Caudal Subscapular N.
K. Axillary (Circumflex) N.
L. Thoraco-dorsal N.
M. Lateral Thoracic N.
N. Radial (Musculospiral) N.
O. Cranial Division of Radial N.
P. Superficial Radial N.
Q. Dorsal Interosseous N.
R. Caudal Division of Radial N.
S. Musculocutaneous N.
T. Medial Cutaneous N.
U. Ulnar N.
V. Median N.

1. Pectoral Muscles
2. First Rib
3. M. Epitrochlearis
4. M. Biceps Brachii
5. Portion of Parotid Gland


1
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G
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A
H
I
M
J
L
N
S
K
5
R
O
Q
P
T
3
U
V
4
1 cm.

FIGURE 12. THE LEFT BRACHIAL PLEXUS

A. Fifth Cervical N. (Ventral Div.)
B. Sixth Cervical N.
C. Seventh Cervical N.
D. Eighth Cervical N.
E. First Thoracic N.
F. Phrenic N.
G. Anterior Thoracic (Pectoral) N.
H. Suprascapular N.
I. Cranial Subscapular N.
J. Caudal Subscapular N.
K. Axillary (Circumflex) N.
L. Thoraco-dorsal N.
M. Lateral Thoracic N.
N. Radial (Musculospiral) N.
O. Cranial Division of Radial N.
P. Superficial Radial N.
Q. Dorsal Interosseous N.
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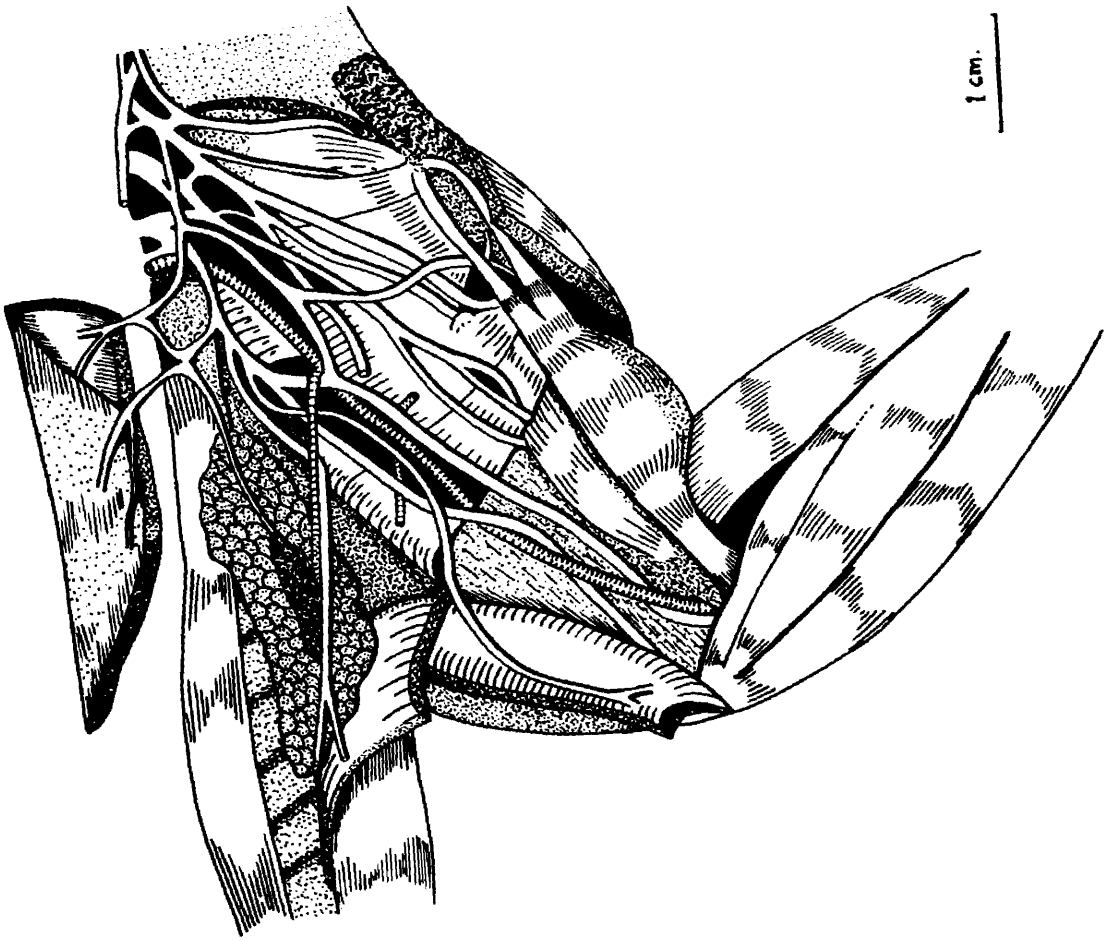
1 cm.

B. THE BRACHIAL PLEXUS

The brachial plexus (fig. 12) is formed primarily by the ventral divisions of the sixth, seventh, and eighth cervical, and the first thoracic nerves. The fifth cervical nerve contributes to the plexus in a minor manner by assisting to the origin of the suprascapular nerves as described below and as illustrated in the figure. No one level is independent, but each is connected to the adjacent levels as illustrated in the figure. The brachial plexus is located in the axilla in close association with the vessels of the axilla in typical mammalian pattern. Some of the nerves innervate the muscles of the shoulder and chest wall, whereas others extend distally into the pectoral limb. Using this criterion, the nerves of the plexus may be grouped as follows:

I. NERVES OF THE SHOULDER AND CHEST-WALL

A) Anterior Thoracic (Pectoral)

B) Suprascapular

C) Subscapular

D) Axillary (Circumflex)

E) Thoraco-dorsal

F) Long Thoracic

G) Lateral Thoracic

II. NERVES OF THE PECTORAL LIMB

A) Radial (Musculospiral)

B) Musculocutaneous

C) Medial cutaneous

D) Ulnar

E) Median

I. NERVES OF THE SHOULDER AND CHEST-WALL:

A) The two Anterior Thoracic (Pectoral) Nerves (G, fig. 12) usually arise from the sixth, seventh, and eighth cervical, and the first thoracic nerves to pass ventrally in association with the anterior thoracic vessels to innervate the pectoral muscles. The nerve arising directly from the sixth and seventh cervical nerves innervates the pectoral muscles at a more cranial level than the anterior thoracic nerve arising from the eighth cervical and first thoracic nerves. The two anterior thoracic nerves are usually interconnected distally by inconsistent rami. At least one thin ramus of variable origin arises from the anterior thoracic nerves to pass to the fat and lymph node of the axilla.

B) The Suprascapular Nerve (H, fig. 12) originates from the fifth and sixth cervical nerves to pass laterad approximately two or three millimeters beneath the clavicle to penetrate the shoulder between the mm. subscapularis and supraspinatus at the distal third of the cranial border of the scapula. From this location the nerve disappears as it penetrates deeply to pass along the supraspinous fossa to

innervate the m. supraspinatus and continue its course to the m. infraspinatus.

C) The Subscapular Nerves usually are two in number. These are referred to in this work as the cranial and caudal subscapular nerves.

a) The cranial subscapular nerve (I, fig. 12) leaves the cranial side of the communicating loop between cervical nerves six and seven. The cranial subscapular nerve passes distad parallel to the suprascapular nerve to enter the m. subscapularis approximately five millimeters caudad of the suprascapular nerve.

b) The caudal subscapular nerve (J, fig. 12) arises from the dorsal side of the axillary nerve. Shortly after its formation the nerve supplies a ramus which contributes to the formation of the thoraco-dorsal nerve as shown in the figure. The caudal subscapular nerve proceeds distad in close association with the axillary nerve to disappear from axillary view a few millimeters dorsad from the axillary nerve.

D) The Axillary (Circumflex) Nerve (K, fig. 12) arises from cervical levels six and seven. This nerve is in close association with the cranial and caudal subscapular nerves as they pass distally. As pointed out previously, the caudal subscapular nerve usually arises from the axillary nerve. In a ventral view, as illustrated in the figure, the axillary nerve passes out of view a few millimeters

from the entrance of the musculocutaneous nerve into the m. biceps brachii. On the lateral side of the upper brachium the axillary nerve emerges from between the deltoids and the lateral head of the triceps muscles in close association with the cephalic vein.

E) The Thoraco-dorsal Nerve (L, fig. 12) arises primarily from the dorsal side of the union of cervical nerves seven and eight. A few millimeters distad to this portion of its origin, the thoraco-dorsal nerve receives a contribution from the caudal subscapular nerve. In this fashion, the sixth cervical nerve aids in the formation of the thoraco-dorsal nerve. The radial nerve usually contributes to the formation of this nerve. This nerve passes caudad, deep to the more caudal nerves of the brachial plexus, across the subscapularis muscle to enter the m. latissimus dorsi, which it supplies.

F) The Long Thoracic Nerve arises from the seventh cervical nerve within the thoracic body wall dorsal to the other nerves described above. This nerve passes caudo-dorsad within the scalenus muscle. At the level of the second rib this nerve emerges to the surface of the m. serratus ventralis, which it supplies.

G) The Lateral Thoracic Nerve (M, fig. 12) arises from cervical nerve eight and thoracic nerve one. The exact point of origin of this nerve varies among different specimens of the same species as well as among different

species, e.g., in the horse (Sisson, p. 836, 1953) this nerve arises by a common trunk with the ulnar nerve. In the dog (Miller, p. 167, 1952) this nerve is a derivative of the pectoral (anterior thoracic) nerves. In the fox squirrel, as illustrated in figure 12, the lateral thoracic nerve arises close to both the ulnar and pectoral nerves. The lateral thoracic nerve follows the blood vessels caudad through the fat of the axilla to remain superficial and supply the cutaneous trunci muscle and skin.

II. NERVES OF THE PECTORAL LIMB:

A) The Radial (Musculospiral) Nerve (N, fig. 12) arises from cervical nerves seven and eight. The origin of this nerve is dorsal to the contribution to the origin of the pectoral nerves from these same cervical nerves. At its origin, or sometimes merely the eighth cervical portion of the origin, the radial nerve usually contributes to the formation of the thoraco-dorsal nerve. The very large radial nerve passes distad cranial and parallel to the median nerve before dividing dichotomously into the following:

a) cranial division

b) caudal (muscular) division

a) The cranial division of the radial nerve (O, fig. 12) is larger than the caudal division. This portion of the nerve may be separated into two subdivisions just before they pass from view around the tendinous portion of

the latissimus dorsi muscle as shown in the figure. Both of these divisions pass deep (laterad) to spiral caudally around the humerus to appear at approximately the middle of the lateral side of the brachium deep to the lateral head of the triceps muscle and superficial to the m. brachialis. The two portions of the cranial division are:

1) Superficial Radial Nerve

2) Dorsal Interosseous Nerve

1) The Superficial Radial Nerve (P, fig. 12) becomes superficial on the lateral side of the brachium between the lateral head of the triceps muscle and the m. brachialis. At this location the superficial radial nerve divides into:

1a) medial branch

1b) lateral branch

1a) The smaller medial branch of the superficial radial nerve (I, fig. 13) passes to the medial (flexor) side of the cephalic vein which it follows distad onto the surface of the antebrachium and passes over the radial surface of the dorsal carpal region. At the proximal level of the metacarpals the medial branch of the superficial radial nerve divides into: (i) a medial branch, the dorsal metacarpal nerve I, which forks to form a medial and a lateral dorsal digital nerve I, each supplying its respective side of the first digit; (ii) a lateral branch which extends to the medial surface of the second digit

where it is known as the medial dorsal digital nerve II. The digital nerves are very small (.2 - .3 mm.) and are therefore difficult to follow in all cases, even with the aid of a dissecting microscope. These nerves tend to follow the blood vessels to their respective sides of the digits. Additional cutaneous rami are given off to the skin at random. The "metacarpal nerves" in this work are sometimes named the "common digital nerves" by many authors (cf. Miller, p. 173, 1952). The "digital nerves" in this work are named "proper digital nerves" by many authors. This inconsistency in terminology is explained in more detail under the "deep ramus of the volar branch of the ulnar nerve".

b) The larger lateral branch of the superficial radial nerve (J, fig. 13) becomes associated with the lateral (extensor) side of the cephalic vein to follow that vessel onto the surface of the dorsal side of the paw. Upon reaching the proximal end of the metacarpus, the nerve divides dichotomously to form: (i) the dorsal metacarpal nerve II, which accompanies its satellite vessels distad within the second intermetacarpal space; and (ii) the dorsal metacarpal nerve III, which extends distad with its satellite vessels within the third intermetacarpal space. Each of these nerves forks to supply adjacent surfaces of the digits; viz., the dorsal metacarpal nerve II supplies contiguous sides of digits two and three via the lateral dorsal digital nerve II and the medial dorsal digital nerve III; the dorsal

metacarpal nerve III supplies adjacent sides of digits three and four by bifurcating to form the lateral dorsal digital nerve III and the medial dorsal digital nerve IV. The contiguous sides of digits four and five, in addition to the lateral side of digit five, are innervated by the dorsal branch of the ulnar nerve as described below. The plan of innervation of the paw as described above consists of the main branches which are constant in location and distribution. There are numerous intercommunicating rami which are very small (.1 mm.) and inconsistent in their distribution.

2) The Dorsal Interosseous Nerve (Q, fig. 12) is the second portion of the cranial division of the radial nerve. This nerve appears on the lateral side of the brachium beneath the lateral head of the triceps muscle and on the surface of the m. brachialis immediately caudal to the superficial radial nerve. Unlike the superficial radial nerve, the dorsal interosseous nerve remains deep in the lateral region of the lower third of the brachium, where it follows the m. brachialis and passes into the antebrachium between the latter muscle and the m. extensor carpi radialis longus. Within the antebrachium, the nerve gives rise to branches which supply the extensor muscles of the forearm.

b) The caudal (muscular) division of the radial nerve (R, fig. 12) does not have as extensive a distribution as the cranial division. This nerve sends a small branch to

the m. epitrochlearis and restricts its ramification to an area proximal to that of the medial cutaneous nerve. The muscular division of the radial nerve proceeds to distribute rami to muscles in the immediate area of the medial head of the triceps and m. coracobrachialis.

B) The Musculocutaneous Nerve (S, fig. 12) arises from the sixth and seventh cervical nerves as a component of a common stem with the pectoral nerve arising from the same cervical nerves. This nerve passes laterad to ventrally cross the axillary nerve immediately before the musculocutaneous nerve passes under the tendinous portion of the short head of the m. biceps brachii at the neck of the humerus. At this location the musculocutaneous nerve gives a branch to the long head of the m. biceps brachii before the nerve turns distad between the two heads of the biceps muscle. In this relationship the musculocutaneous nerve extends toward the antebrachium to give off branches to the mm. coracobrachialis and brachialis in the distal half of the brachium. A branch of the musculocutaneous nerve passes under the m. biceps brachii near its insertion to enter the antebrachium. Within this portion of the pectoral limb the nerve remains superficial, to pass caudad as the medial cutaneous antebrachial nerve. This nerve passes caudad as far as the carpal region where it remains superficial to the median nerve to distribute cutaneous rami at random to the carpal region and medial side of the first digit.

C) The Medial Cutaneous Nerve (T, fig. 12) arises from the eighth cervical and first thoracic nerves as a slender nerve from the caudal end of a nerve loop formed by cervical nerves six and seven cranially, and eighth cervical and first thoracic nerves caudally. The origin of this nerve is close to the origins of the ulnar and lateral thoracic nerves. Near its origin this nerve sometimes lies between the ulnar and median nerves; but distally it follows the cranial border of the m. epitrochlearis. After passing beyond the border of this muscle, the nerve enters the antebrachial fascia where its superficial rami are lost to view as they innervate the integument of the local area.

D) The Ulnar Nerve (U, fig. 12; A, fig. 13) arises from the eighth cervical and first thoracic nerves immediately distal to the origin of the medial cutaneous nerve. The ulnar nerve is greater in diameter than the medial cutaneous nerve. The ulnar nerve passes distad in close association with the median nerve and the brachial artery. In the distal half of the brachium the ulnar nerve curves dorsally around the brachial artery and accompanies the median nerve as it passes dorsal to the same artery. Both nerves lie parallel as they proceed toward the olecranon. The ulnar nerve extends deep (lateral) to the m. anconeus and curves around the medial epicondyle of the humerus just prior to entering the antebrachium beneath the m. flexor carpi ulnaris. The ulnar nerve remains in this same re-

lative position as far as the middle of the antebrachium where it bifurcates into the following:

a) Volar Branch

b) Dorsal Branch

a) The Volar Branch (C, fig. 13) arises from the ulnar nerve and immediately gives origin to a cutaneous branch which passes to the flexor surface of the antebrachium. Here the cutaneous branch extends distad on the surface of the m. palmaris longus and ramifies to supply the integument of that area. The volar branch then continues distad with a branch of the ulnar artery mediad to the tendon of the m. flexor carpi ulnaris. The nerve then passes ventral to the os pisiformis to enter the manus where it immediately bifurcates into the following:

1) A superficial ramus (D, fig. 13) extends distad to supply the most proximal lateral pad of the vola before continuing to the lateral surface of the fifth digit as the lateral volar digital nerve V.

2) The deep ramus (E, fig. 13) of the volar branch of the ulnar nerve leaves its parent stem to curve mediodorsad around the tendon of the m. flexor carpi ulnaris. It then passes toward the radial side of the manus dorsal to the tendons of the mm. flexor digitorum sublimis and flexor digitorum profundus to innervate muscles of the metacarpus. In the fox squirrel no terminal rami of the deep ramus of the volar branch of the ulnar nerve could be

found to anastomose with superficial metacarpal nerves to form the "common volar digital nerves" as described for the dog by Miller (p. 179, 1952). Many authors use the term "common volar (palmar) digital nerves" to denote the same nerves referred to in this work as the "metacarpal nerves", e.g., in the human (Toldt, p. 832, 1948), and in the rat (Greene, p. 125, 1935). Greene (p. 125, 1935) and Miller (p. 179, 1952) use the same terminology, but with a different definition in the strictest sense of the word, i.e., the "common volar digital nerves" as used by Greene (p. 125, 1935) by definition are not the same as the "common volar digital nerves" as used by Miller (p. 179, 1952). In addition to the discrepancy in terminology of the nerves discussed above, the branches of these nerves are referred to in this work as the "digital nerves", but in many references these same nerves are named "proper digital nerves".

b) The Dorsal Branch (B, fig. 13) arises from the ulnar nerve at the same level as does the volar branch. The dorsal branch passes distad to appear on the lateral surface of the distal fourth of the antebrachium as illustrated in the figure. The nerve then passes to the ulnar side of the dorsal surface of the manus. The nerve accompanies arterial branches to the fourth and fifth digits as follows: a branch to the lateral side of the fifth digit is the lateral dorsal digital nerve V. After giving

off this branch the nerve extends within the fourth intermetacarpal space as the dorsal metacarpal nerve IV; which bifurcates into the lateral dorsal digital nerve IV and the medial dorsal digital nerve V, to the contiguous dorsal sides of the fourth and fifth digits.

The areas innervated by the dorsal branch of the ulnar nerve in the fox squirrel as described above are similar to those of the dorsal branch as found in the rat by Greene (p. 125, 1935). The distribution of the terminal rami of the volar branch of the ulnar nerve of the fox squirrel is not as extensive as that of the rat according to the same author. As explained in detail under the median nerve, the more extensive distribution of the terminal rami of the median nerve in the fox squirrel appears to compensate for this apparent meager distribution of the ulnar nerve when compared with the rat according to the author cited above.

E) The Median Nerve (V, fig. 12; F, fig. 13) arises from the last three cervical and the first thoracic nerves as described below and illustrated in figure 12. The cranial branch of its origin is from cervical levels six and seven by means of a prominent branch from the more cranial pectoral nerve. The caudal branch of the median nerve's origin is directly from the anastomosis of portions of cervical nerve eight and thoracic nerve one. These two branches of origin meet to form a large nerve loop, as explained previously, and the median nerve arises from the

FIGURE 13. INNERVATION OF THE VOLAR SURFACE OF FOREPAW

A. Ulnar N.

B. Dorsal Branch of Ulnar N.

C. Volar Branch of Ulnar N.

D. Superficial Ramus of Volar Branch

E. Deep Ramus of Volar Branch

F. Median N.

G. Volar Metacarpal Nn. (Common Digital Nn.)

H. Volar Digital Nn. (Proper Digital Nn.)

I. Medial Br. of Superficial Radial N. (pulled craniad)

J. Lateral Br. of Superficial Radial N. (pulled craniad)

1. M. Extensor Carpi Radialis

2. M. Flexor Carpi Radialis

3. M. Palmaris

4. M. Flexor Carpi Ulnaris

5. Cephalic Vein

I. First Digit

V. Fifth Digit

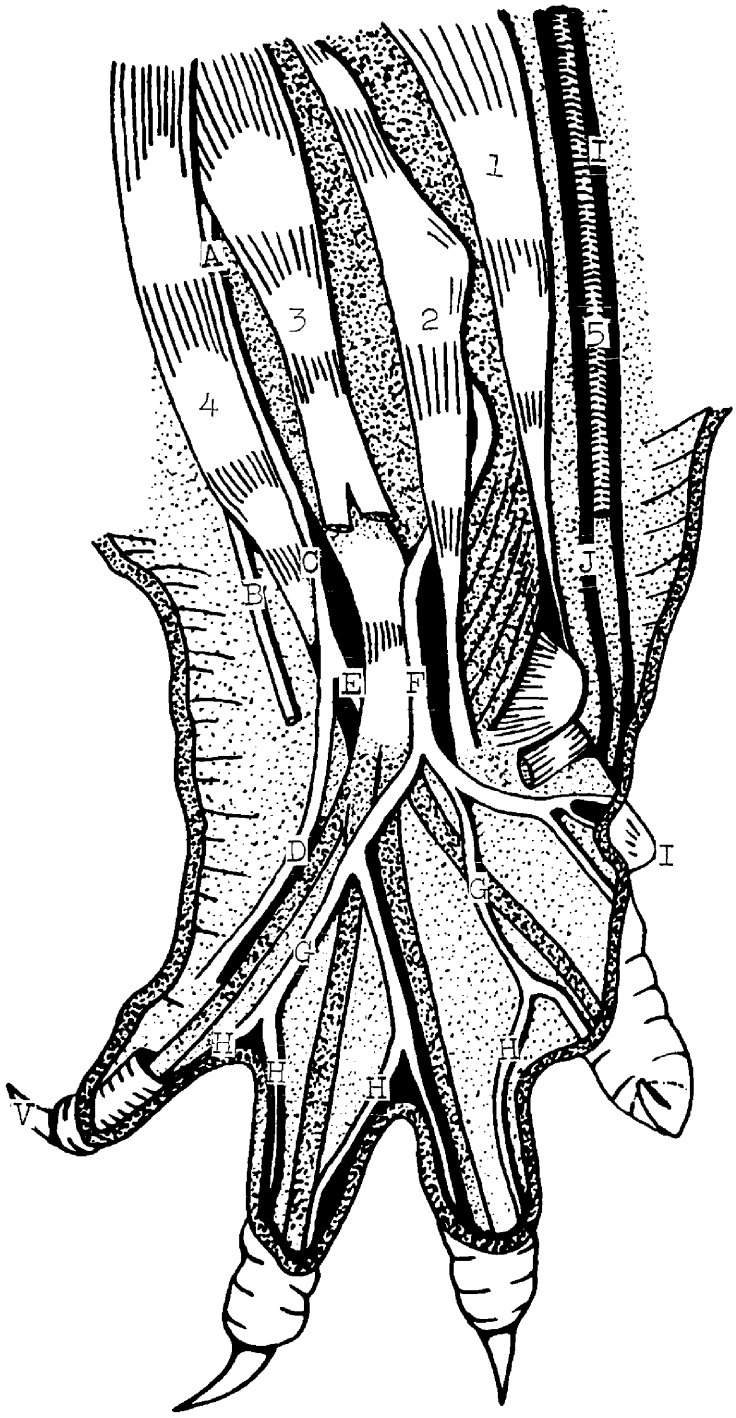
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FIGURE 13. INNERVATION OF THE VOLAR SURFACE OF FOREPAW

A. Ulnar N.

B. Dorsal Branch of Ulnar N.

C. Volar Branch of Ulnar N.

D. Superficial Ramus of Volar Branch

E. Deep Ramus of Volar Branch

F. Median N.

G. Volar Metacarpal Nn. (Common Digital Nn.)

H. Volar Digital Nn. (Proper Digital Nn.)

I. Medial Br. of Superficial Radial N. (pulled craniad)

J. Lateral Br. of Superficial Radial N. (pulled craniad)

1. M. Extensor Carpi Radialis

2. M. Flexor Carpi Radialis

3. M. Palmaris

4. M. Flexor Carpi Ulnaris

5. Cephalic Vein

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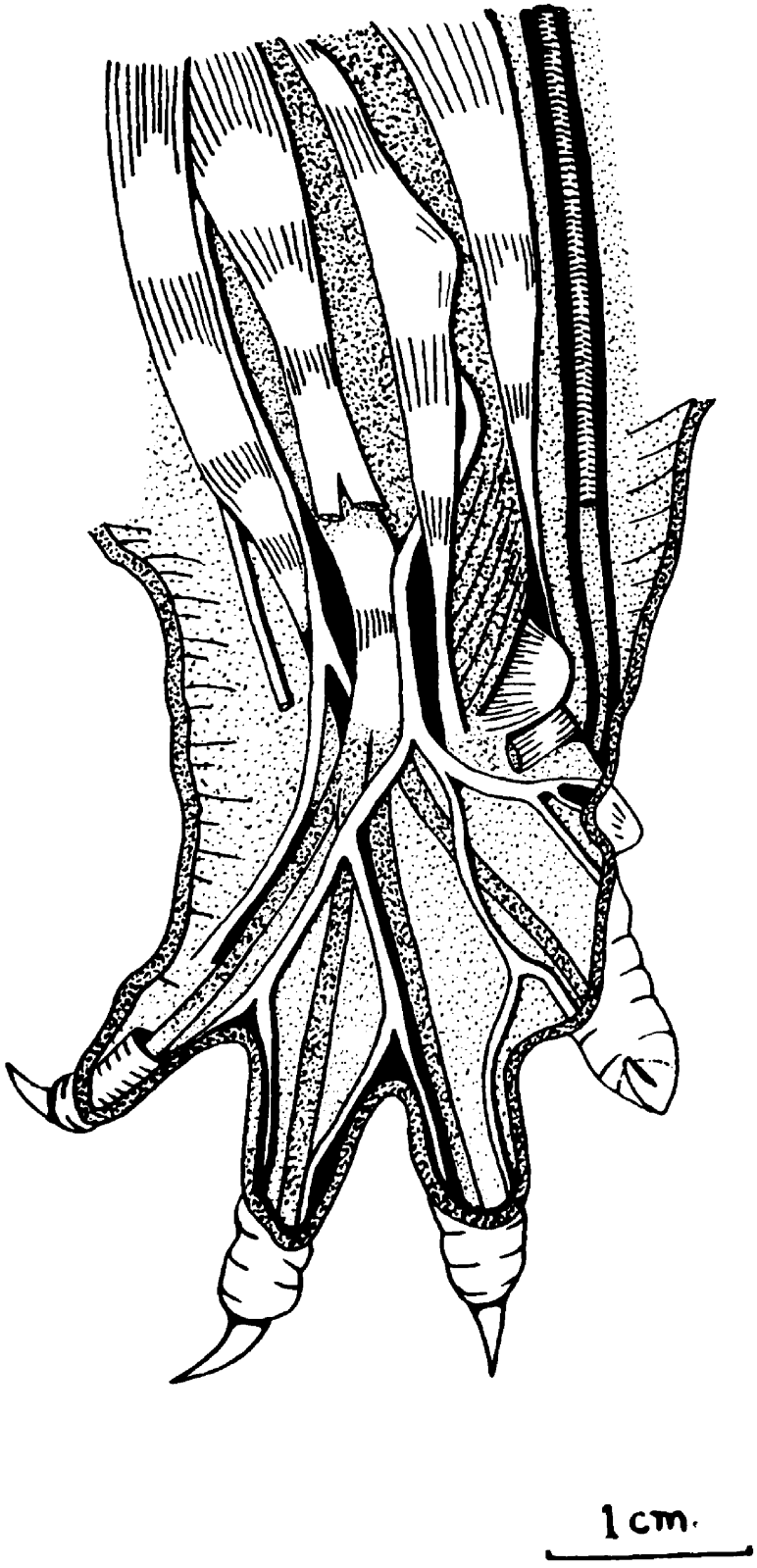
V. Fifth Digit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most distal point of the loop. The median nerve runs parallel and craniad to the brachial artery, which usually separates the median nerve from the musculocutaneous and ulnar nerves. No branches arise from the median nerve while it is within the brachium; but upon passing through the supracondyloid foramen to enter the antebrachium beneath the m. pronator teres, it gives rise to branches which innervate the following muscles: pronator teres, flexor carpi radialis, palmaris longus, flexor digitorum profundus, and pronator quadratus. Therefore, the median nerve innervates the flexor and pronator muscles of the antebrachium, with exception of the m. flexor carpi ulnaris. This arrangement of the innervation while within the antebrachium is similar to that in the cat according to Reighard and Jennings (p. 390, 1940).

After giving rise to the above named branches in the proximal portion of the antebrachium, the median nerve continues distad in company with the radial artery. The nerve appears on the flexor surface of the forearm between the pronator teres and the flexor carpi radialis muscles before dividing just proximal to the transverse ligament as illustrated in figure 13. In some specimens this division appears as a bifurcation; in other specimens there are formed three resulting branches. The exact point of division varies among different specimens. If only two branches are formed from this division, as illustrated in

the figure, the following details are demonstrable with the aid of a dissecting microscope:

a) The division on the radial side immediately divides again to result in volar metacarpal nerve I and volar metacarpal nerve II. The volar metacarpal nerve I follows the first intermetacarpal space to divide into: (1) the medial and lateral volar digital nerves I to the respective sides of the first digit; (2) the medial volar digital nerve II to the medial side of the second digit. The volar metacarpal nerve II follows the second intermetacarpal space to bifurcate into the lateral volar digital nerve II and medial volar digital nerve III, to supply contiguous sides of the second and third digits (cf. fig. 13).

b) The division of the median nerve on the ulnar side of the vola passes distad toward the lateral side and divides into: (1) the volar metacarpal nerve III and (2) volar metacarpal nerve IV. The former nerve extends distad and bifurcates into the lateral volar digital nerve III and the medial volar digital nerve IV, which supply contiguous sides of the third and fourth digits. The volar metacarpal nerve IV follows the fourth intermetacarpal space to bifurcate into the lateral volar digital nerve IV and the medial volar digital nerve V to the contiguous sides of the fourth and fifth digits.

The volar metacarpal nerve IV and its branches, viz., the lateral volar digital nerve IV and medial volar digital nerve V, are peculiar to the fox squirrel when compared with such mammals as the rat (Greene, p. 125, 1935), cat (Reighard and Jennings, p. 392, 1940), human (Durward, p. 1074, 1951), and dog (Miller, p. 179, 1952). These species have no such arrangement of innervation for the volar surfaces of the fourth and fifth digits as described above for the fox squirrel. In each of the references cited above the adjacent sides of the fourth and fifth digits are supplied by digital branches from the ulnar nerve, rather than from the median nerve as described above and illustrated for the fox squirrel. As explained under the ulnar nerve, this more extensive distribution of the median nerve to include the adjacent sides of the fourth and fifth digits in the fox squirrel appears to compensate for the extremely limited distribution of the ulnar nerve within the vola, viz., the lateral side of the fifth digit.

FIGURE 14. THE CONSTRUCTION OF THE SPINAL NERVE (THORACIC REGION)

A. Spinal Cord

B. Dorsal Root

C. Ventral Root

D. Dorsal Root Ganglion

E. Spinal Nerve Proper (Trunk)

F. Dorsal Primary Division

G. Ventral Primary Division (Intercostal N.)

H. Ramus Communicans

I. Paravertebral Ganglion of Thoracic Trunk

J. Medial Branch of Dorsal Division

K. Lateral Branch of Dorsal Division

1. Centrum of Vertebra

2. Transverse Process

3. Spinous Process

4. Tuberculum of Rib

5. Capitulum of Rib

6. Epaxial Muscle Mass

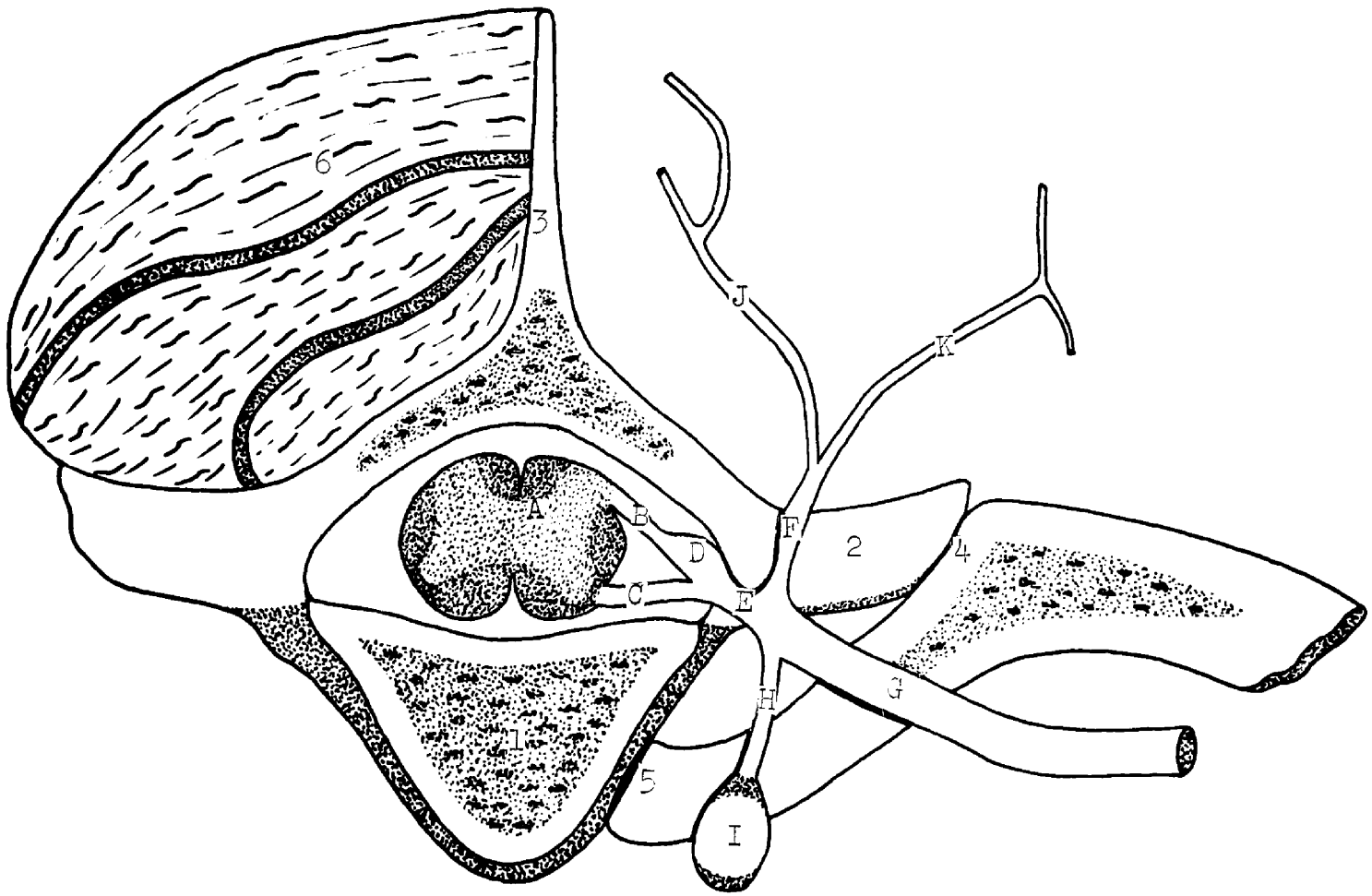
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FIGURE 14. THE CONSTRUCTION OF THE SPINAL NERVE (THORACIC REGION)

A. Spinal Cord

B. Dorsal Root

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E. Spinal Nerve Proper (Trunk)

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1. Centrum of Vertebra

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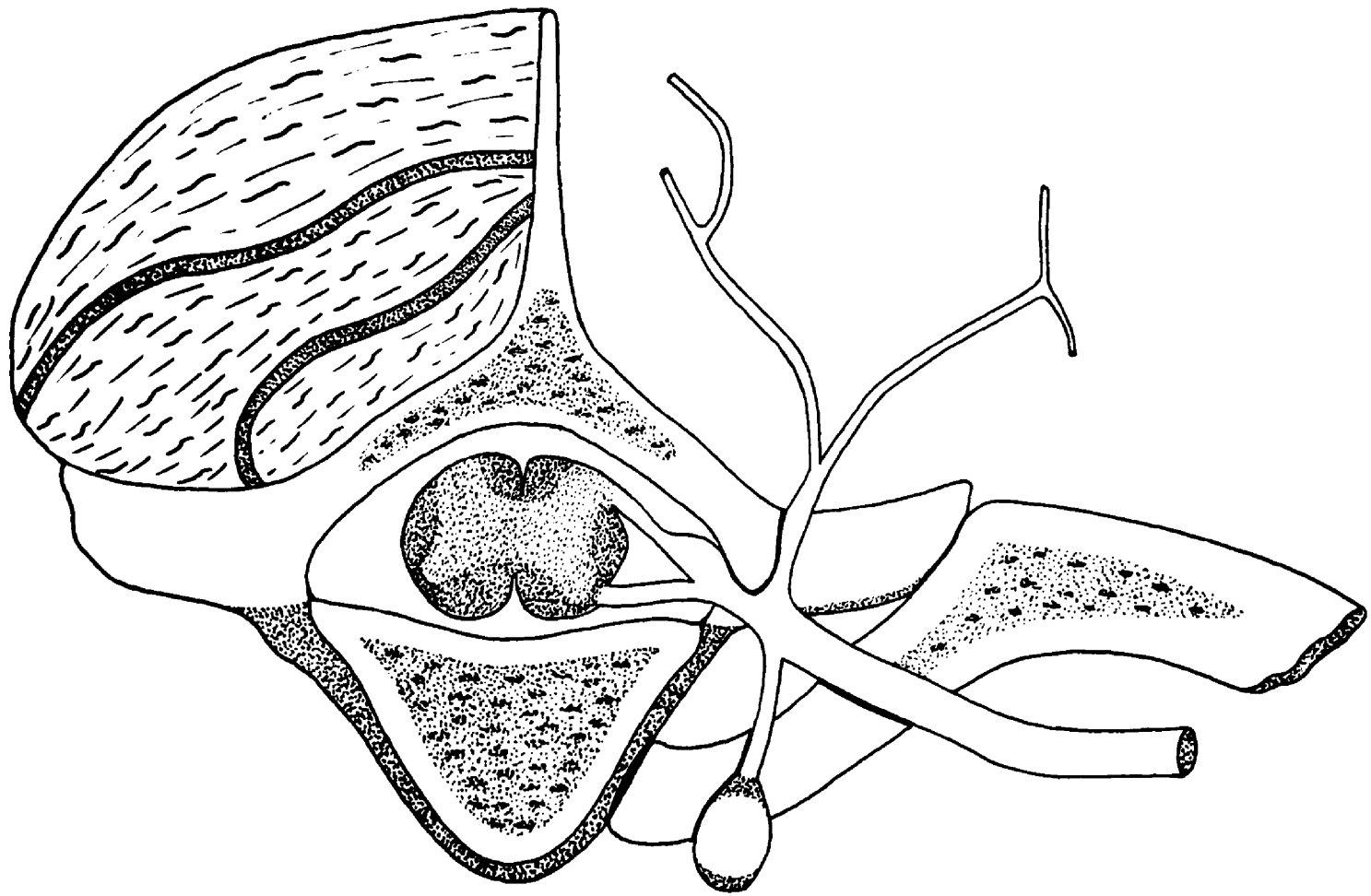
5. Capitulum of Rib

6. Epaxial Muscle Mass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C. THE THORACIC NERVES

(Fig. 14)

Each of the thirteen pairs of thoracic nerves in the fox squirrel is designated according to the vertebra immediately craniad to the emergence of the nerve from the vertebral column. The general anatomy of a typical thoracic nerve is given below. With the exception of the first thoracic nerve, which contributes to the brachial plexus, this general consideration may pertain to any one of the thoracic nerves.

The thoracic nerve of the fox squirrel demonstrates best the typical example of the spinal nerve as described previously in the introduction to the spinal nerves and illustrated in the figure. The ventral primary division of the spinal nerve in the thoracic region passes distally within the intercostal space as the intercostal nerve. This nerve traverses laterocraniad within the intercostal space to reach the intercostal vessels at the caudal surface of the preceeding rib and follows these vessels distally to approach the sternum. The cranio-caudal arrangement of the intercostal nerve and vessels in this location is: rib, vein, artery, and nerve. Near the origin of the ventral division, rami communicantes connect the spinal nerve with the ganglionated trunk (cord).

Branches of the Ventral Division (Intercostal Nerve):

The intercostal nerve (ventral division of the spinal nerve) gives rise to three rami as follows:

a) Shortly after accompanying the vessels, the intercostal nerve gives rise to a branch, the dorsal cutaneous branch, which pierces the intercostal muscles to supply the superficial muscles and integument in the area immediately ventral to the epaxial muscle mass.

b) At approximately the middle of the rib a second ramus, the lateral cutaneous branch (nerve), pierces the thoracic wall to supply the superficial muscles and integument on the lateral surface of the body.

c) As the intercostal nerve approaches the transversus costarum and rectus abdominus muscles, which it supplies, the nerve gives rise to small irregular branches, the ventral cutaneous branches (nerves), which become superficial to supply the muscles adjacent to the sternum and the integument of the area.

The first thoracic nerve is an exception to the general plan of the typical thoracic nerve. The large ventral division of the first thoracic nerve contributes primarily to the brachial plexus as described above. Usually this is the only thoracic nerve which contributes to this plexus. From the ventral division of the first thoracic nerve there is a small branch, the first intercostal nerve, to the first intercostal space.

FIGURE 15. A SUPERFICIAL DISSECTION OF THE RIGHT LUMBAR PLEXUS

A. Twelfth Thoracic N. (Ventral Division)
B. Thirteenth Thoracic N.
C. Iliohypogastric N.
D. Ilio-inguinal N.
E. Lateral Cutaneous N. of the Thigh
F. Femoral N.
G. Genitofemoral N.

1. Liver (sectioned)
2. Posterior Vena Cava
3. Dorsal Aorta
4. Adrenal Gland (left)
5. Kidney
6. Twelfth Rib and Intercostal Vessels
7. Renal Vessels
8. Ureter
9. Coeliac A.
10. Cranial Mesenteric A.
11. Urinary Bladder
12. Rectum
13. Psoas Muscles
14. M. quadratus lumborum
15. Abdominal Wall Muscles
16. Femoral Vessels
17. Iliolumbar Vessels

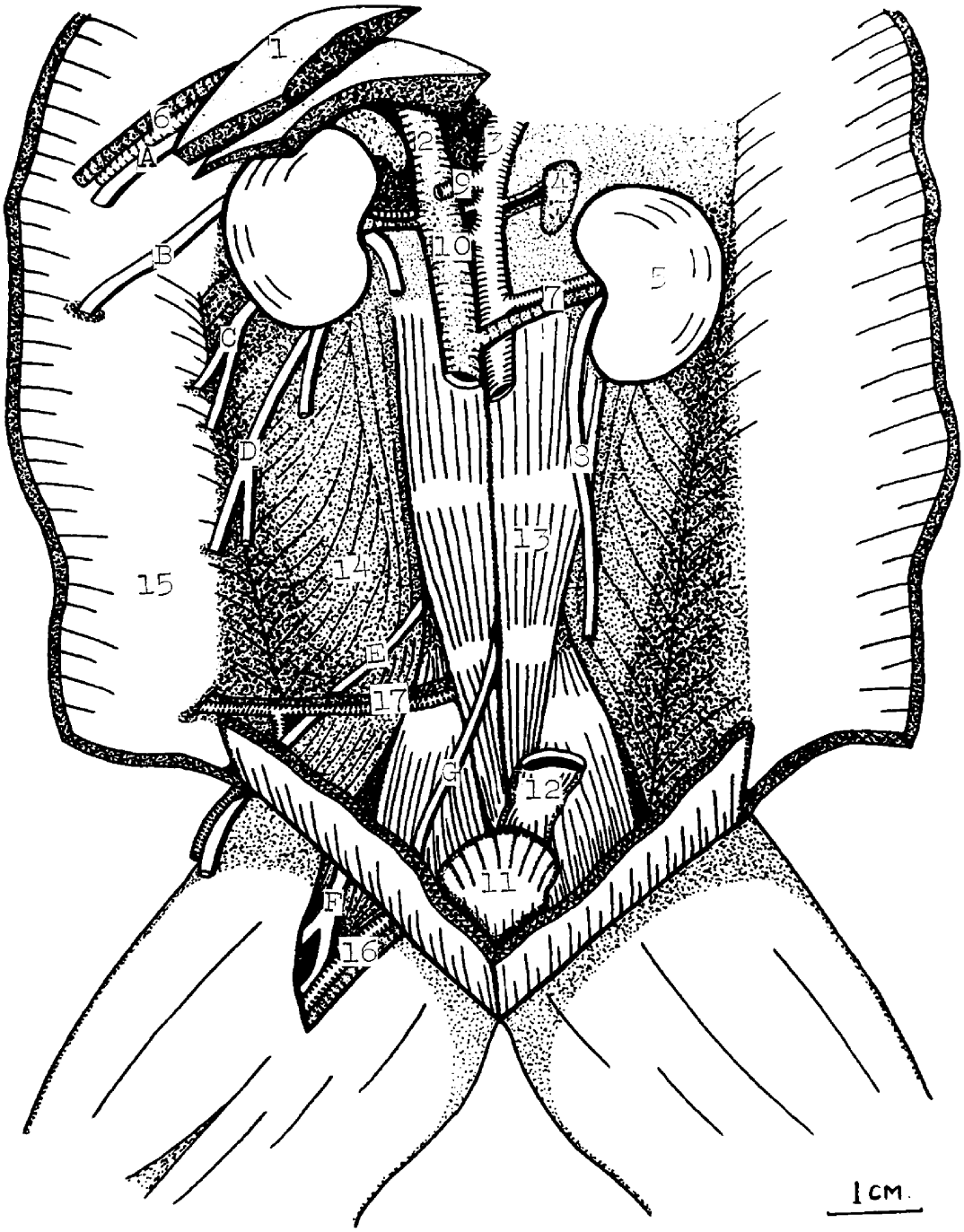
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FIGURE 15. A SUPERFICIAL DISSECTION OF THE RIGHT LUMBAR PLEXUS

A. Twelfth Thoracic N. (Ventral Division)
B. Thirteenth Thoracic N.
C. Iliohypogastric N.
D. Ilio-inguinal N.
E. Lateral Cutaneous N. of the Thigh
F. Femoral N.
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4. Adrenal Gland (left)
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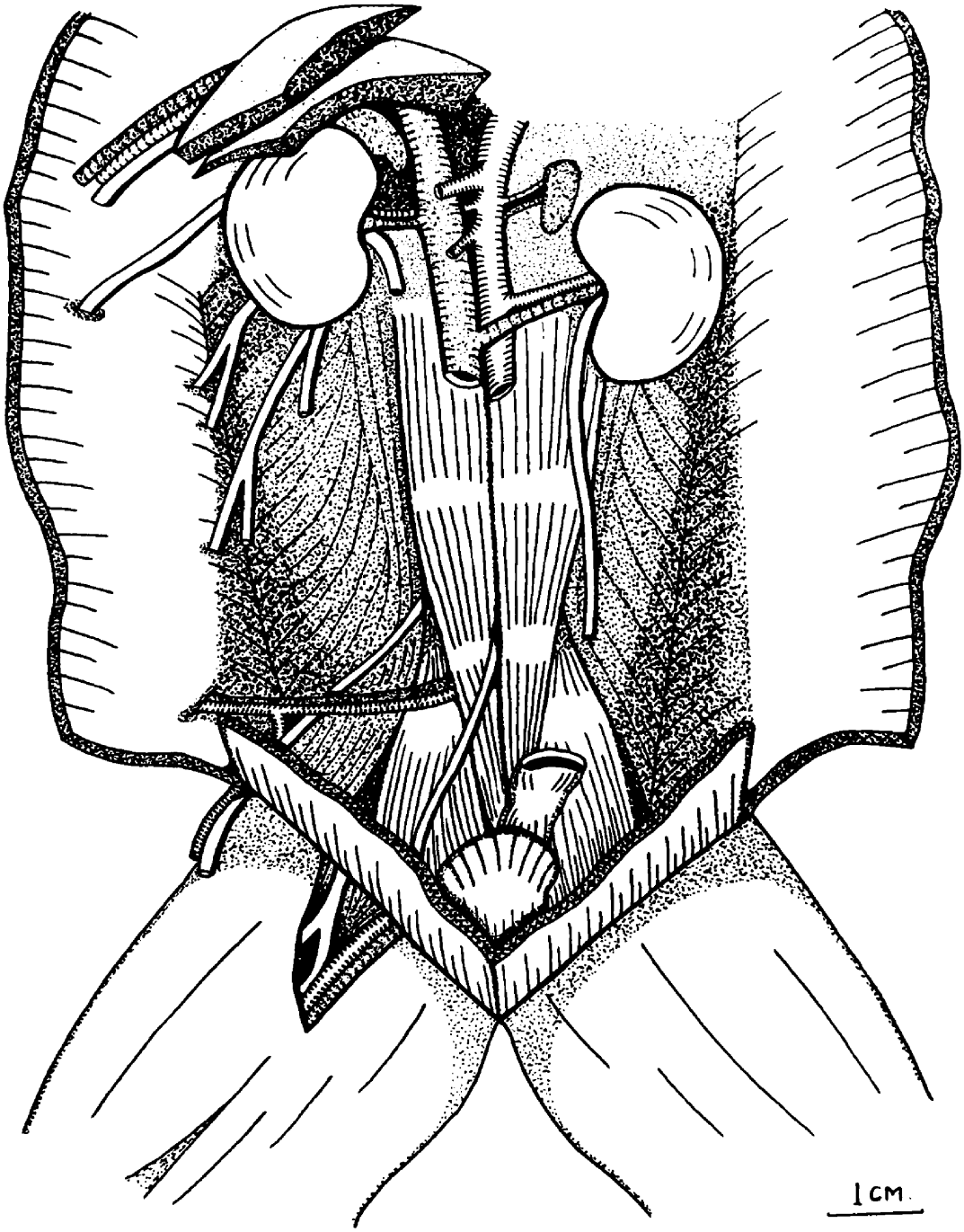
9. Coeliac A.
10. Cranial Mesenteric A.
11. Urinary Bladder
12. Rectum
13. Psoas Muscles
14. M. quadratus lumborum
15. Abdominal Wall Muscles
16. Femoral Vessels
17. Iliolumbar Vessels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D. THE LUMBO-SACRAL PLEXUS
(Figs. 15,16,18,19)

In the fox squirrel the lumbo-sacral plexus is formed by the ventral divisions of the spinal nerves lumbar one to sacral two, inclusive. As the name implies, this plexus may be conveniently subdivided into two major portions, lumbar and sacral. These subdivisions are somewhat arbitrary, for these is no exact demarcation between the two portions.

The lumbo-sacral plexus shows considerable variation; not only among various mammalian species, but among different specimens within the same species. The lumbar portion of the plexus demonstrates this variability much more frequently than does the more caudal portion of the plexus. As a general rule, the demonstrable variability rests upon the presence or absence of interconnecting rami between the first and second, and second and third lumbar nerves. In some species the three cranial lumbar nerves are included within the plexus; in other species they are not included. In those species which have the first three lumbar levels interconnected, the three cranial lumbar nerves usually are included within the plexus; whereas if the individual nerves course independently as separate entities from one origin, they usually are not included within the lumbar plexus. As illustrated in figure 16, in the fox squirrel the first three lumbar nerves sometimes

are interconnected and therefore are considered as contributing to the composition of the lumbar plexus. This figure illustrates only one arrangement found by the author. In some specimens interconnecting rami could be found between neither lumbar one and two, nor two and three; whereas in other specimens only one of the two intersegmental rami was discernible. Other species in which the first three lumbar nerves are included within the lumbar plexus are: rat (Greene, p. 127, 1935), man (Durward, p. 1090, 1951), and monkey (Howell and Straus, p. 318, 1933). Species in which the first three lumbar nerves are not included within the lumbar plexus are: cat (Hyman, p. 496, 1947), and horse (Sisson, p. 844, 1953). According to Bradley (p. 141, 1948), in the dog all seven lumbar nerves enter into the formation of the lumbo-sacral plexus; whereas Sisson (p. 877, 1953) does not include the first two lumbar nerves as a portion of the plexus in the same species.

The portions of the body supplied by the terminals of the nerves contributing to the lumbo-sacral plexus are: pelvic viscera, muscles of the abdominal wall, rump, perineum, and hind limb. The innervation of the pelvic viscera is by the components of the autonomic nervous system and therefore is not considered in this work. The other portions of the body innervated by these nerves are considered below in detail. The two divisions of the plexus are considered separately.

FIGURE 16. A DEEP DISSECTION OF THE RIGHT LUMBAR PLEXUS

A. Thirteenth Thoracic N. (ventral div.)
B. Iliohypogastric N.
C. Ilio-inguinal N.
D. Lateral Cutaneous N. of the Thigh
E. Genitofemoral N. (pulled laterally)
F. Femoral N.
G. Obturator N.
H. Lumbo-sacral Trunk
I. Ramus muscularis

1. Psoas muscles (cut)
2. M. quadratus lumborum
3. Muscles of the Abdominal Wall
4. Tendinous origin of the Diaphragm
5. First Lumbar Vertebra
6. Third Lumbar Vertebra
7. Sixth Lumbar Vertebra

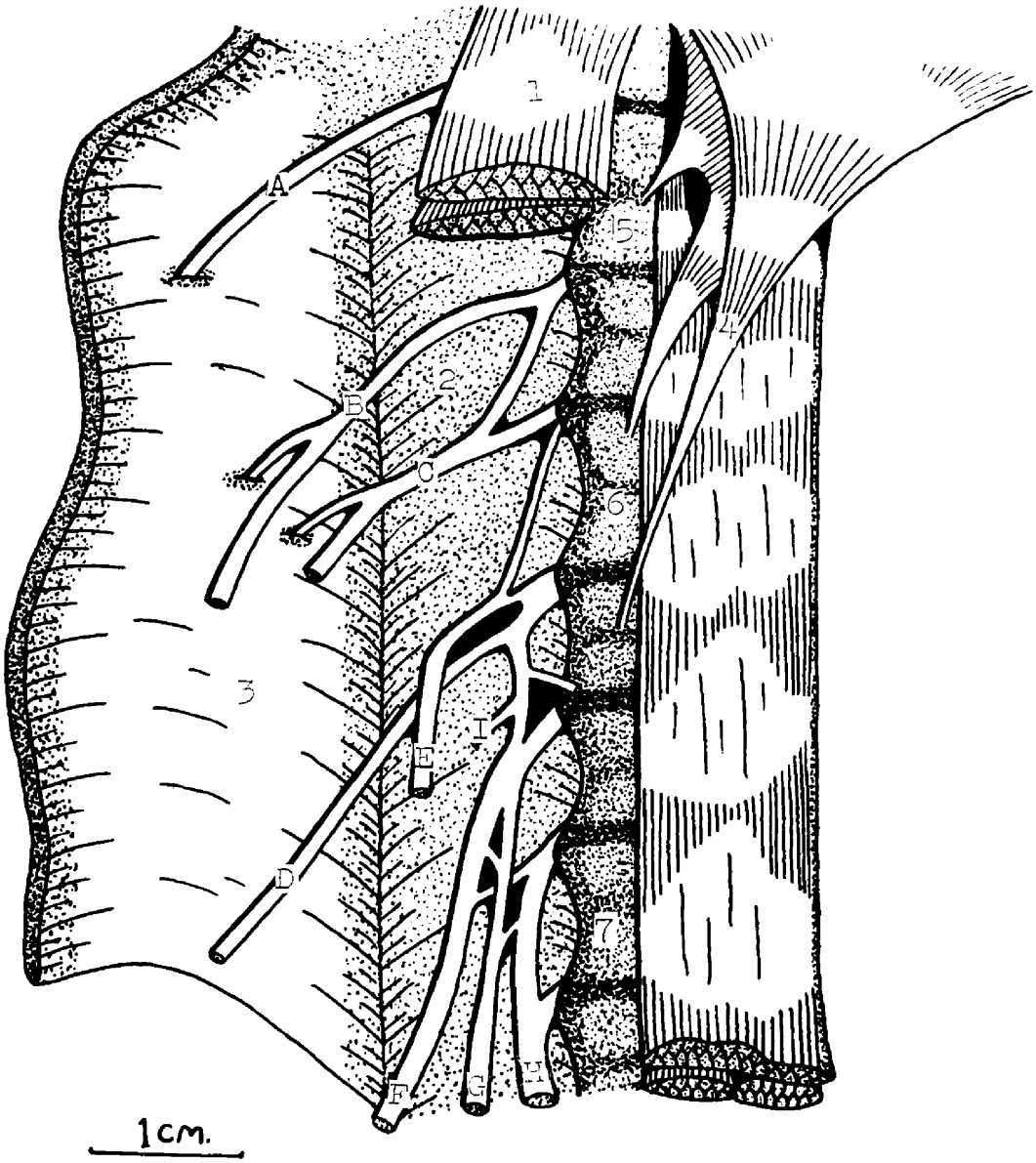
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FIGURE 16. A DEEP DISSECTION OF THE RIGHT LUMBAR PLEXUS

A. Thirteenth Thoracic N. (ventral div.)
B. Iliohypogastric N.
C. Ilio-inguinal N.
D. Lateral Cutaneous N. of the Thigh
E. Genitofemoral N. (pulled laterally)
F. Femoral N.
G. Obturator N.
H. Lumbo-sacral Trunk
I. Ramus muscularis

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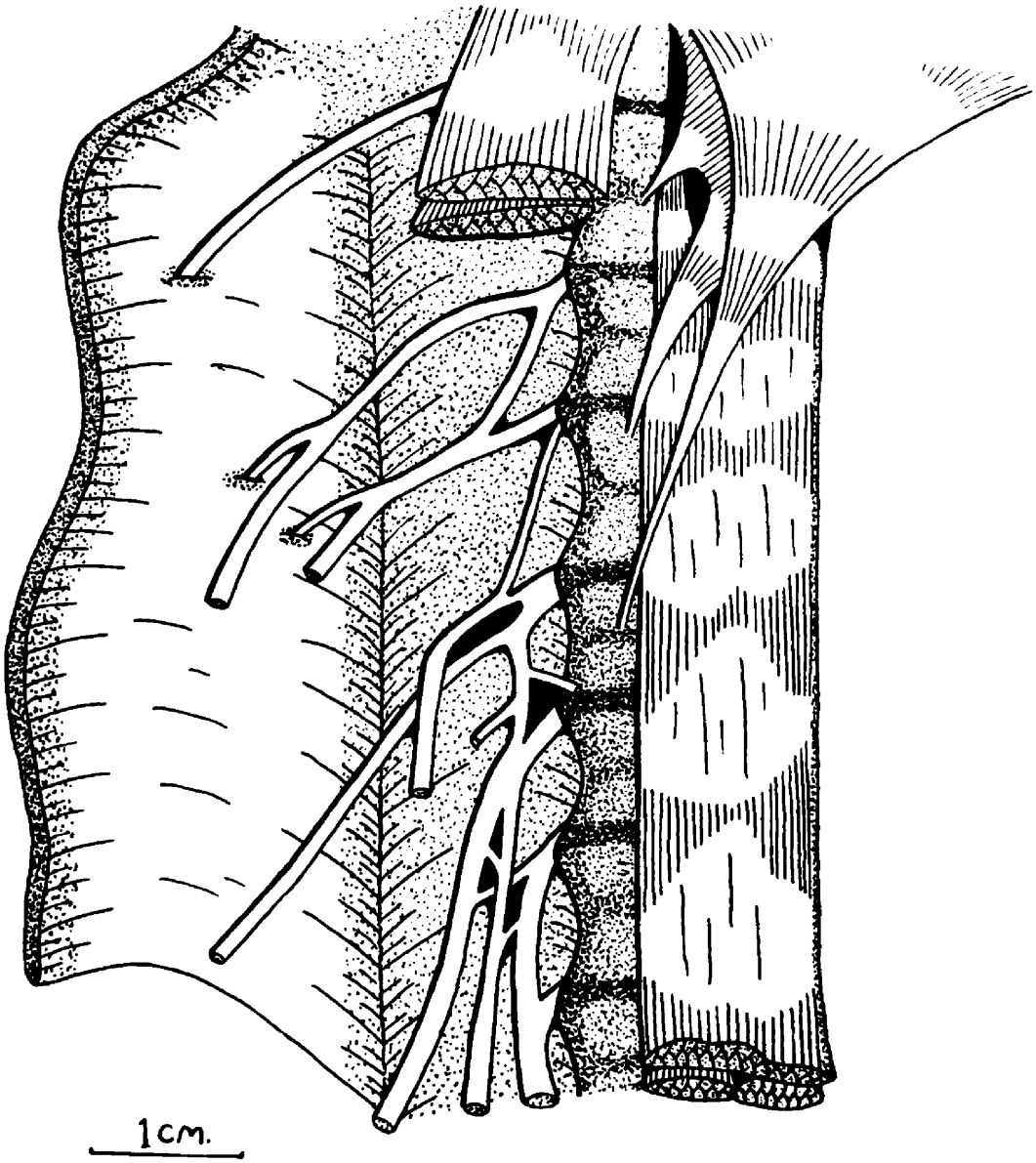
6. Third Lumbar Vertebra
7. Sixth Lumbar Vertebra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I. LUMBAR PLEXUS

(Figs. 15,16,17)

The lumbar plexus is formed by the ventral divisions of the first four or five lumbar nerves. As stated above, there is no exact anatomical separation between the lumbar and sacral plexuses. Figure 16 shows that the fifth lumbar nerve contributes to both plexuses. The lumbar plexus is located within the psoas muscle, ventral to the transverse processes of the lumbar vertebrae. The nerves are connected ventrally to the autonomic ganglionated cord by means of rami communicantes. Distally the lumbar nerves, particularly the first three, give rise to cutaneous branches, which pierce the body wall to appear superficially to innervate the cutaneous maximus muscle and skin in a segmental pattern.

The individual nerves which contribute to the lumbar plexus, listed in order according to origins, are as follows:

A) Iliohypogastric
B) Ilio-inguinal
C) Genitofemoral
D) Lateral Cutaneous N. of thigh
E) Femoral
F) Obturator

A) The Iliohypogastric Nerve (C, fig. 15; B, fig. 16) emerges from the first lumbar nerve to pass caudolaterad across the ventral surface of the quadratus lumborum muscle

dorsal to the kidney. This nerve pierces the abdominal body wall immediately caudad to the kidney as shown in figure 15. Distally this nerve gives rise to a prominent branch which passes caudad before penetrating the body wall to appear subcutaneously. It innervates the cutaneous maximus muscle and skin. Near its origin, this nerve sometimes gives rise to a communicating branch which passes caudad to join the ilio-inguinal nerve.

B) The Ilio-inguinal Nerve (D, fig. 15; C, fig. 16) arises from the second, or sometimes first and second lumbar nerves to pass distally somewhat parallel to the iliohypogastric nerve. The formation of this nerve occurs approximately at the level of the hilus of the right kidney. This nerve passes caudolaterad to emerge from beneath the caudal border of the kidney to penetrate the lateral body wall caudal to the iliohypogastric nerve as illustrated in the figures.

C) The Genitofemoral Nerve (G, fig. 15; E, fig. 16) originates from the third lumbar, or sometimes from the second and third lumbar nerves to pass ventrally and emerge from the psoas muscle approximately at the midline (fig. 15). The nerve then proceeds caudally dorsal to the ureter toward the inguinal region where it bifurcates to form the following nerves:

a) Lumboinguinal

b) External Spermatic

FIGURE 17. THE SUPERFICIAL BRANCHES OF THE FEMORAL AND OBTURATOR NERVES (MEDIAL ASPECT)

A. Femoral N.

B. Saphenous N.

C. Branch to M. Quadriceps femoris

D. Obturator N. (anterior division)

E. Branch to M. Adductor longus

F. Branch to M. Gracilis

1. M. Iliacus

2. M. Psoas

3. M. Pectineus

4. M. Rectus femoris

5. M. Vastus medialis

6. M. Gracilis

7. M. Tensor fasciae latae

8. M. Semitendinosus

9. Ilioinguinal (Poupart's) ligament

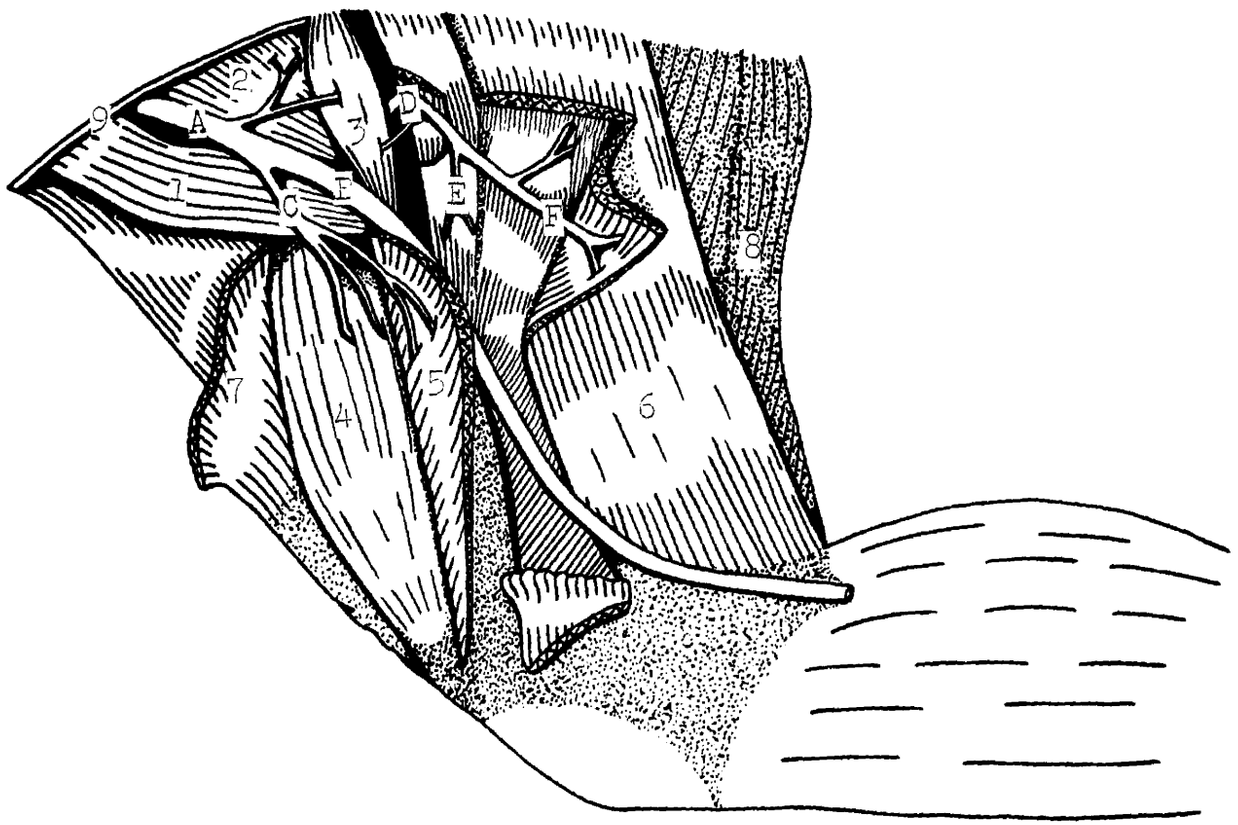

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FIGURE 17. THE SUPERFICIAL BRANCHES OF THE FEMORAL AND OBTURATOR NERVES (MEDIAL ASPECT)

A. Femoral N.

B. Saphenous N.

C. Branch to M. Quadriceps femoris

D. Obturator N. (anterior division)

E. Branch to M. Adductor longus

F. Branch to M. Gracilis

1. M. Iliacus

2. M. Psoas

3. M. Pectineus

4. M. Rectus femoris

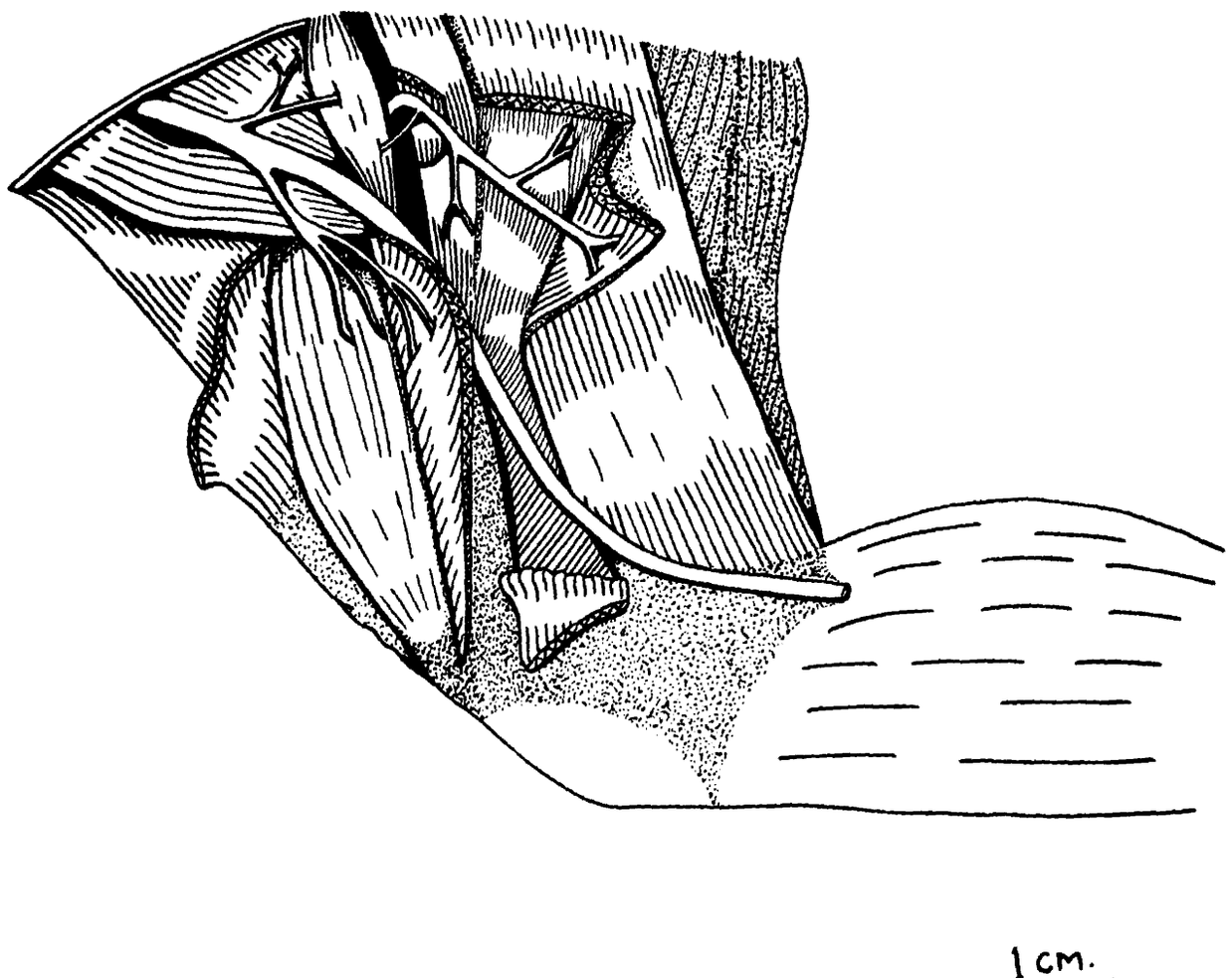
5. M. Vastus medialis

6. M. Gracilis

7. M. Tensor fasciae latae

8. M. Semitendinosus

9. Ilioinguinal (Poupart's) ligament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a) Lumboinguinal Nerve:

The lumboinguinal nerve proceeds to penetrate the body wall beneath the inguinal ligament to become a cutaneous branch in the area of the femoral triangle.

b) External Spermatic Nerve:

In the male the external spermatic nerve crosses the external iliac vessels to follow the exterior of the cremaster muscle into the inguinal canal with the ductus deferens and the external spermatic vessels. It supplies the cremaster muscle and inguinal lymph nodes before passing to the exterior of the scrotum and adjacent portions of the thigh.

In the female the external spermatic nerve supplies the inguinal mammae, inguinal lymph nodes, vulva, and surrounding area of the thigh.

D) The Lateral Cutaneous Nerve of the Thigh (E, fig. 15; D, fig. 16) arises primarily from the third lumbar nerve in close association with the genitofemoral nerve. This nerve passes in a caudolaterad direction dorsal to the genitofemoral nerve to become associated with the iliolumbar vessels as shown in figure 15. In the region of the superior iliac spine this nerve pierces the body wall to appear on the lateral surface of the thigh where its branches are distributed cutaneously.

E) The Femoral Nerve (F, fig. 15; F, fig. 16; A, fig. 17) arises from the third, fourth, and fifth lumbar nerves to pass caudad deep between the iliacus and psoas muscles. This nerve emerges to the surface as it passes under the inguinal ligament lateral to the femoral vessels to appear on the medial surface of the thigh.

After passing under the inguinal ligament the femoral nerve gives rise to constant muscular branches to: (a) the pectineus and iliacus muscles on the proximal side; and (b) on the distal side the nerve sends muscular rami (C, fig. 17) to the components of the quadriceps femoris. After giving origin to the above named rami, the terminal branch of the femoral nerve is the Saphenous Nerve (B, fig. 17). This nerve remains superficial to follow the saphenous vessels distally along the medial surface of the thigh and shank to continue to the medial side of the tarsus from where cutaneous branches are distributed to the medial side of the foot.

F) The Obturator Nerve (G, fig. 16; D, fig. 17; C, fig. 19) arises from lumbar nerves four and five in an indirect manner, viz., the contribution from the fourth nerve is by way of the femoral nerve, and the fifth lumbar nerve contributes to the origin of the lumbo-sacral trunk and femoral nerve in addition to the obturator nerve. The degree of contribution from the fifth lumbar nerve varies. In some specimens there was a small branch from this level as

shown in the figures; in other specimens there was a rather extensive fusion between the obturator nerve and the fifth lumbar contribution to the lumbo-sacral trunk. The formation of the obturator nerve occurs deep within the psoas muscle where the nerve immediately passes caudad to enter the true pelvis. In this position the obturator nerve is deep (dorsal) to the common iliac vessels, where it joins the obturator branch of the internal iliac artery and follows it through the obturator foramen to enter the thigh.

Upon entering the deep portion of the thigh, the obturator nerve divides into the following:

a) Anterior Division

b) Posterior Division

a) Anterior Division:

The anterior division of the obturator nerve sends a ramus to the hip joint and then passes to the surface to emerge from between the pectineus and adductor longus muscles as illustrated in figure 17. The anterior division then proceeds caudomediad to supply the adductor longus, pectineus and gracilis muscles before terminating as the cutaneous branch to the medial surface of the thigh.

b) Posterior Division:

The posterior division of the obturator nerve remains deep beneath the adductor muscles of the thigh. The closely associated muscles innervated by this division are: the adductor magnus, adductor brevis, quadratus femoris, and obturator externus.

FIGURE 18. A SUPERFICIAL DISSECTION OF THE SACRAL AND PUDENDAL PLEXUSES

(LATERAL VIEW)

A. Sciatic N.

B. Posterior Cutaneous N. of the Thigh

C. Pudendal N.

D. Dorsal N. of the Penis

E. Perineal N.

F. Inferior Gluteal N.

G. Superior Gluteal N.

1. M. tensor fasciae latae

2. M. vastus lateralis

3. M. gastrocnemius

4. M. biceps femoris

5. M. bulbocavernosus

6. Gluteal Muscles

7. Superior Gluteal Fossa of Ilium

8. Tuberosity of Ischium

9. Greater Trochanter of Femur

10. Third Trochanter of Femur

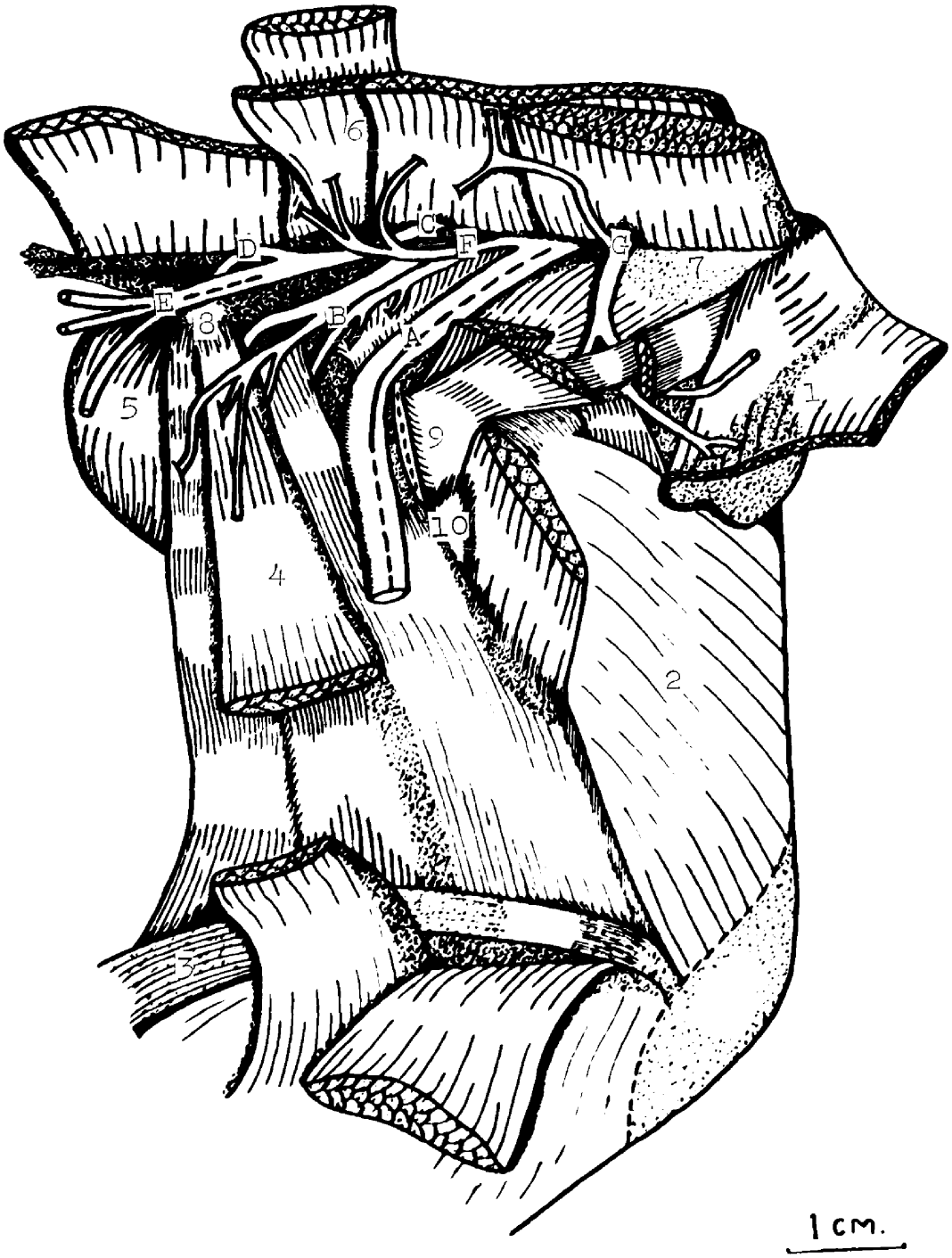
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FIGURE 18. A SUPERFICIAL DISSECTION OF THE SACRAL AND PUDENDAL PLEXUSES

(LATERAL VIEW)

A. Sciatic N.

B. Posterior Cutaneous N. of the Thigh

C. Pudendal N.

D. Dorsal N. of the Penis

E. Perineal N.

F. Inferior Gluteal N.

G. Superior Gluteal N.

1. M. tensor fasciae latae

2. M. vastus lateralis

3. M. gastrocnemius

4. M. biceps femoris

5. M. bulbocavernosus

6. Gluteal Muscles

7. Superior Gluteal Fossa of Ilium

8. Tuberosity of Ischium

9. Greater Trochanter of Femur

10. Third Trochanter of Femur

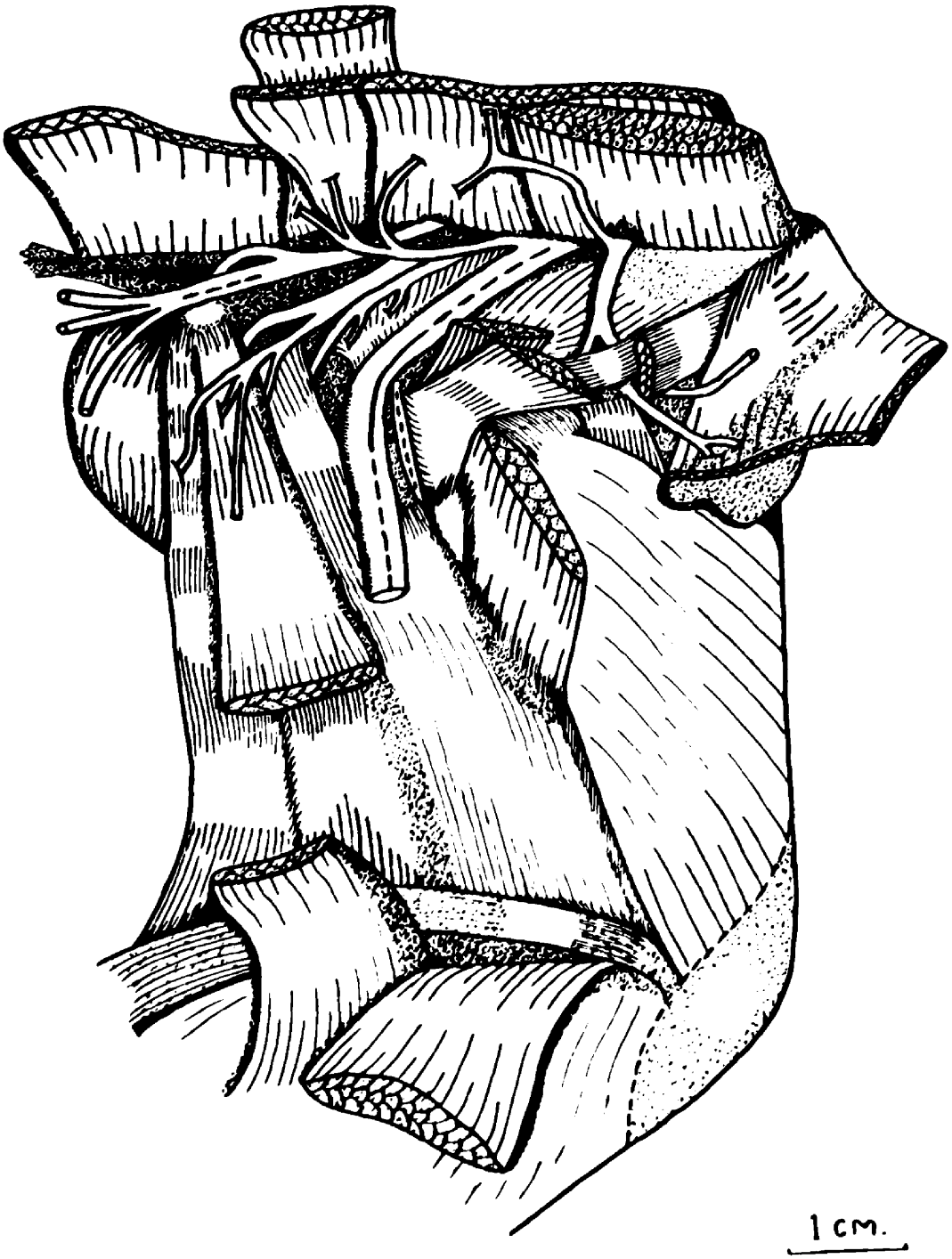

1 cm.

FIGURE 19. A DEEP DISSECTION OF THE SACRAL AND PUDENDAL PLEXUSES

A. Femoral N.

B. Superior gluteal N.

C. Obturator N.

D. Inferior gluteal N.

E. Lumbo-sacral Trunk

F. Sciatic N.

G. Posterior cutaneous N. of the Thigh

H. Pudendal N.

I. Ventral Posterior Caudal Trunk

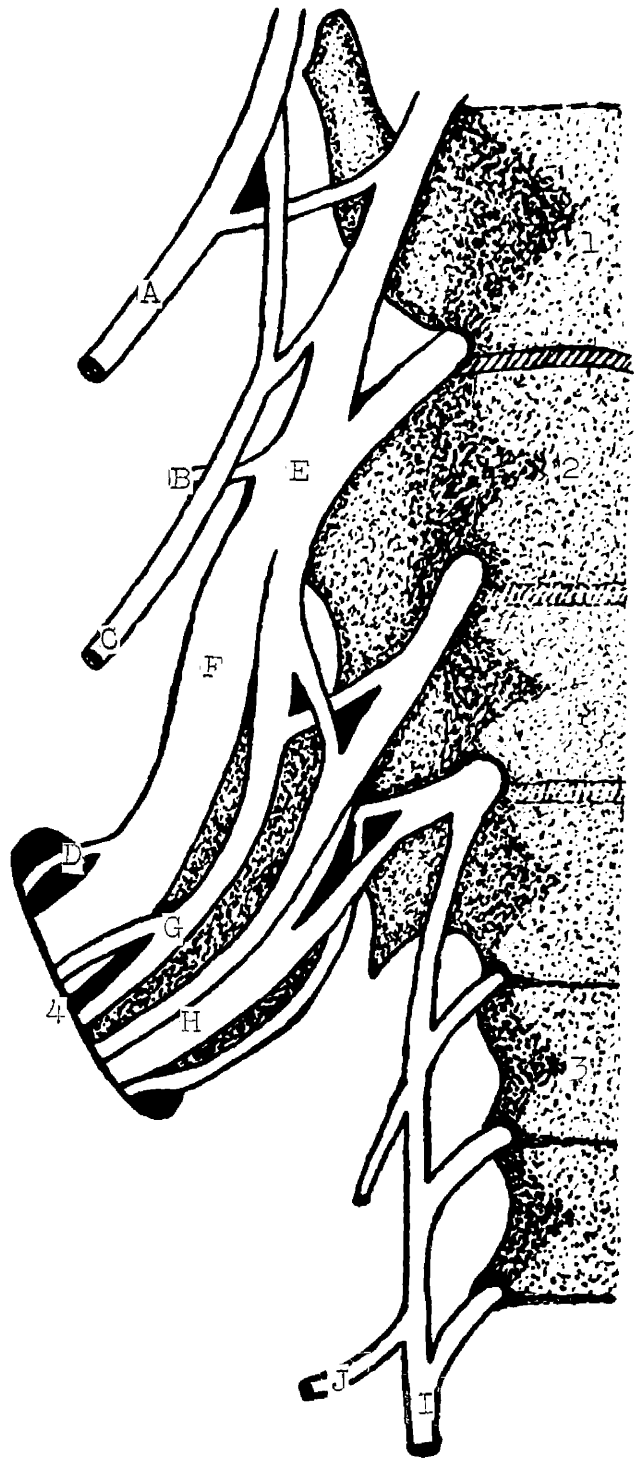
J. Ramus to caudal muscles and Skin

1. Sixth Lumbar Vertebra

2. First Sacral Vertebra

3. First Coccygeal Vertebra

4. Sciatic Foramen



1 cm.

FIGURE 19. A DEEP DISSECTION OF THE SACRAL AND PUDENDAL PLEXUSES

A. Femoral N.

B. Superior gluteal N.

C. Obturator N.

D. Inferior gluteal N.

E. Lumbo-sacral Trunk

F. Sciatic N.

G. Posterior cutaneous N. of the Thigh

H. Pudendal N.

I. Ventral Posterior Caudal Trunk

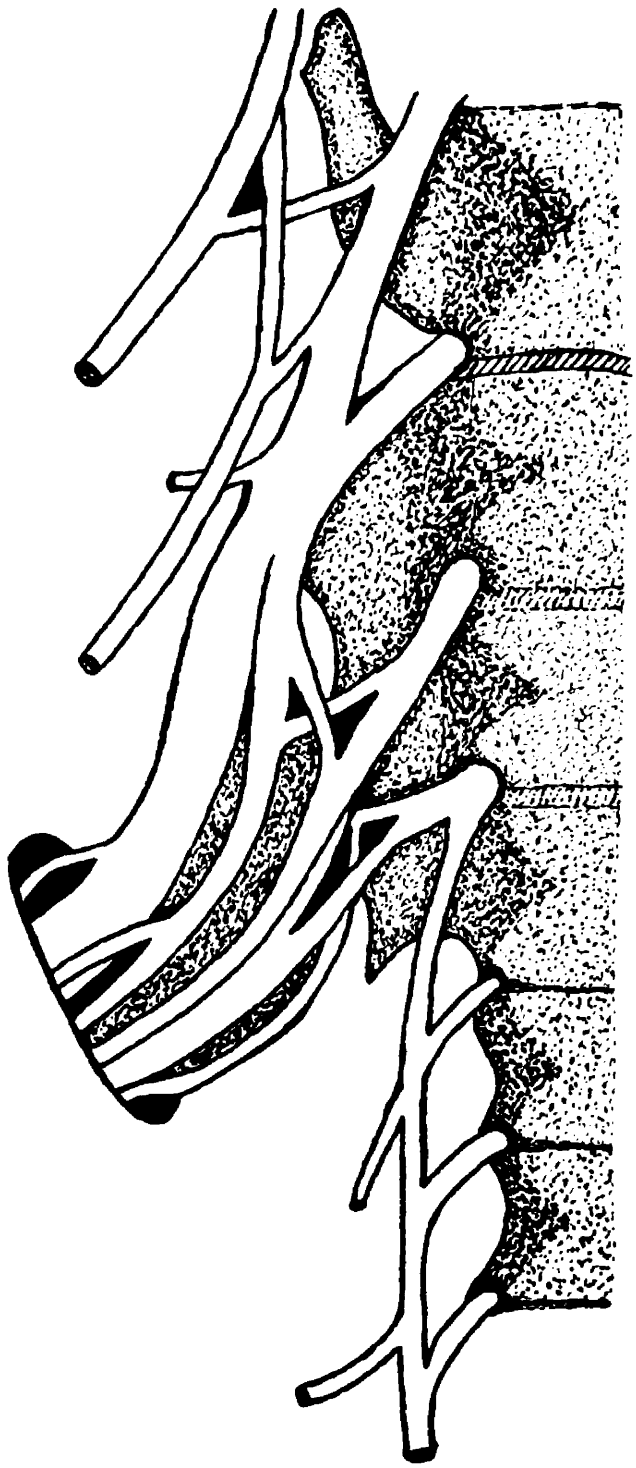
J. Ramus to caudal muscles and Skin

1. Sixth Lumbar Vertebra

2. First Sacral Vertebra

3. First Coccygeal Vertebra

4. Sciatic Foramen



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II. SACRAL PLEXUS

(Figs. 18,19)

The sacral plexus is formed by contributions from the ventral divisions of the last two (fifth and sixth) lumbar and the first two sacral nerves as illustrated in figure 19. The nerves of the sacral plexus are found on the dorsal wall of the true pelvis as they pass toward the perineum and hind limb.

The major terminal nerves arising from the sacral plexus, as described below, are the following:

A) Superior Gluteal

B) Inferior Gluteal

C) Sciatic

The fifth and sixth lumbar nerves give rise to anastomotic nerves which form the lumbo-sacral trunk (E, fig. 19).

A) The Superior Gluteal Nerve (G, fig. 18; B, fig. 19) arises directly from the lateral border of the lumbo-sacral trunk. It appears as though most or perhaps all of its fibers should come from the fifth lumbar nerve. This nerve passes dorsolaterad to curve laterally over the dorsal border of the ilium in close association with the gluteal and piriformis muscles. The course of the nerve is illustrated in figure 18 as it proceeds toward the deep surface of the m. tensor fasciae latae, which it innervates.

B) The Inferior Gluteal Nerve (F, fig. 18; D, fig. 19) is a small nerve which originates either from the lateral side of the distal end of the lumbo-sacral trunk (cord) or from the sciatic nerve as it separates from the trunk. This nerve leaves the pelvis along with the sciatic and other nerves as illustrated in figure 19. The inferior gluteal nerve appears on the dorsolateral side of the hip dorsal to the sciatic nerve and caudal to the superior gluteal nerve in the region of the m. gluteus maximus, which it supplies.

C) The Sciatic Nerve (A, fig. 18; F, fig. 19) arises from the fifth and sixth lumbar levels as the lateral extension of the lumbo-sacral trunk. This very large nerve leaves the pelvis by passing through sciatic foramen in close association with the other nerves of the plexus as illustrated in figure 19.

After leaving the pelvis, the sciatic nerve appears on the lateral side of the rump. At first observation in this location the nerve appears to be a single nerve, but closer examination reveals the sciatic to be a compound nerve consisting of two major and several collateral divisions having a common sheath which binds them together. This sheath usually extends distally as far as the level shown in figure 20. Upon dissection, this sheath is easily removed, especially in a nonpreserved animal, and therefore the divisions of the sciatic nerve may be separated at a much higher level than that shown in figure 20. This figure

illustrates the most common appearance of the nerve as it lies undisturbed in the thigh deep to the m. biceps femoris.

Upon removal of the common sheath and separation of the divisions of the sciatic nerve up to the hip region, one can separate the smaller outside components much more easily than the larger inner components. The two inner large components are: the common peroneal (external popliteal) nerve, and the tibial (internal popliteal) nerve. In the proximal third of the thigh the latter lies caudad to the former. These two large components are generally considered as the two primary divisions of the sciatic nerve. At the level of the third trochanter these two divisions give rise to branches which pass distally within the common sheath to the popliteal fossa where they branch and continue to the shank and foot as described below.

DIVISIONS OF THE SCIATIC NERVE TO THE SHANK AND FOOT:

I. Common Peroneal (External Popliteal)
   1) N. to M. Biceps Femoris Anticus
   2) Superficial Peroneal (Musculocutaneous)
   3) Deep Peroneal (Anterior Tibial)

II. Tibial (Internal Popliteal)
   1) N. to M. Biceps Femoris Posticus
   2) Sural
   3) N. to Lateral Head of M. Gastrocnemius
   4) N. to Medial Head of M. Gastrocnemius

5) Medial Plantar

6) Lateral Plantar

I. Common Peroneal (External Popliteal) Division (Nerve):

As stated previously, in the proximal third of the thigh the common peroneal division (C, fig. 20) of the sciatic nerve lies craniad to the tibial division. The common peroneal division is slightly smaller in diameter than the tibial division. This positional relationship between the two nerves remains fairly constant as they pass distally in the thigh between the adductor muscles and the m. biceps femoris. As these two nerves near the popliteal fossa, however, the larger tibial nerve passes mediad and sometimes appears to cross under the common peroneal nerve in a short inconsistent course toward the knee joint before passing caudad into the shank. The intimate relationship with regard to whether or not the tibial nerve crosses under the peroneal depends upon the degree of flexion of the limb at the knee, viz., the greater the flexion; the slacker the nerve. This slackness under this condition, permits the above mentioned crossing; but upon straightening the limb, this crossing is nonexistant and the tibial nerve merely traverses the popliteal fossa mediad to enter the shank between the two heads of the gastrocnemius muscle as described below.

At approximately the level of the third trochanter the common peroneal nerve gives rise to the following nerve:

1) The Nerve to the M. Biceps Femoris Anticus (H, fig. 20) is a slender nerve which remains intimately within the common sciatic sheath craniad to its parent stem as it passes distad to the level shown in the figure, where it leaves to pass to the m. biceps femoris anticus near the tibial insertion of the latter.

After giving rise to this nerve, the common peroneal nerve continues distad beyond the popliteal fossa; below the lateral side of the knee the nerve divides into the following:

2) Superficial Peroneal (Musculocutaneous) Nerve

3) Deep Peroneal (Anterior Tibial) Nerve

2) The Superficial Peroneal (Musculocutaneous) Nerve (F, fig. 20) leaves the common peroneal nerve as it crosses the neck of the fibula deep to the m. biceps femoris. This nerve accompanies the peroneal vessels and passes distad deeply to the peroneus longus muscle. In the lower half of the shank the nerve becomes superficial on the lateral surface as shown in the figure. The nerve continues distally to cross over the transverse crural (annular) ligament in front of the lateral malleolus to reach the dorsum of the foot. Here the nerve ramifies to follow the superficial blood vessels to supply the dorsum of the foot and digits as follows: the superficial peroneal nerve gives rise to

FIGURE 20. A SUPERFICIAL DISSECTION OF THE POPLITEAL FOSSA (LATERAL ASPECT)

A. Sciatic N.

B. Sural N.

C. Common Peroneal N.

D. Tibial N.

E. Deep Peroneal N.

F. Superficial Peroneal N.

G. N. to M. biceps femoris posticus

H. N. to M. biceps femoris anticus

I. N. to M. gastrocnemius (lateral head)

J. N. to M. gastrocnemius (medial head)

1. M. vastus lateralis

2. M. biceps femoris anticus

3. M. biceps femoris posticus

4. M. peronaeus longus

5. M. gastrocnemius (lateral head)

6. M. gastrocnemius (medial head)

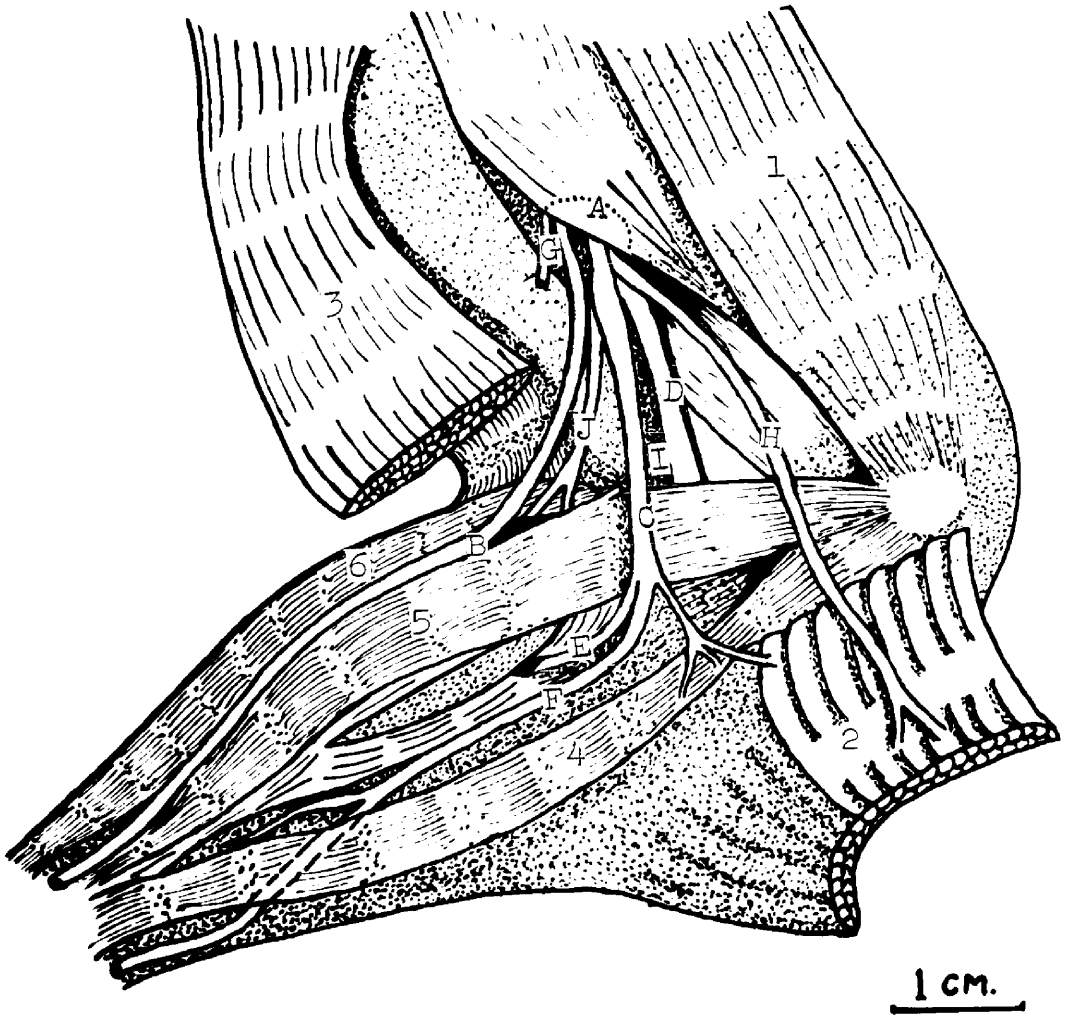
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FIGURE 20. A SUPERFICIAL DISSECTION OF THE POPLITEAL FOSSA (LATERAL ASPECT)

A. Sciatic N.

B. Sural N.

C. Common Peroneal N.

D. Tibial N.

E. Deep Peroneal N.

F. Superficial Peroneal N.

G. N. to M. biceps femoris posticus

H. N. to M. biceps femoris anticus

I. N. to M. gastrocnemius (lateral head)

J. N. to M. gastro nemius (medial head)

1. M. vastus lateralis

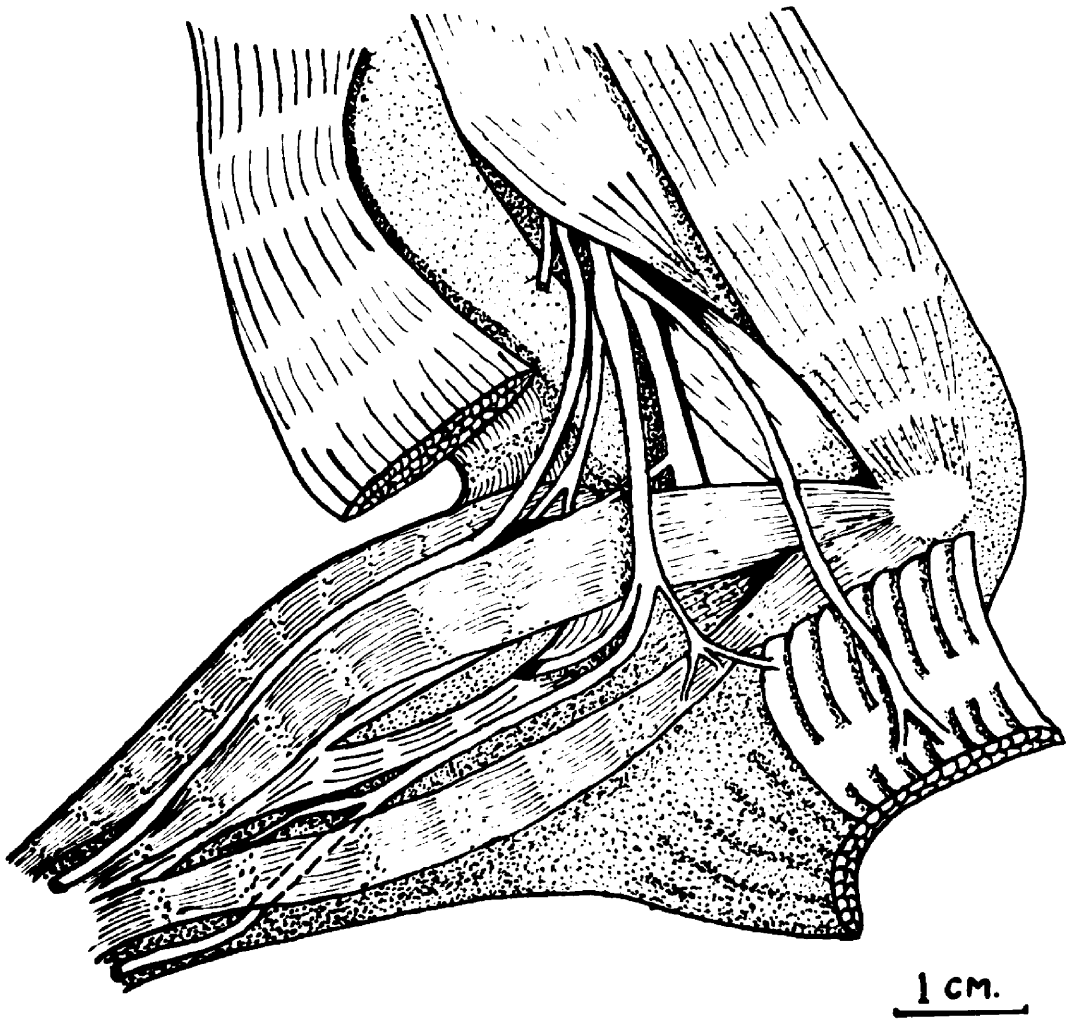
2. M. biceps femoris anticus

3. M. biceps femoris posticus

4. M. peronaeus longus

5. M. gastrocnemius (lateral head)

6. M. gastrocnemius (medial head)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the dorsal metatarsal nerves I, III, and IV which follow the respective intermetatarsal spaces. Upon reaching the distal ends of the metatarsals, these dorsal metatarsal nerves bifurcate into dorsal digital nerves which supply the contiguous sides of digits one and two, three and four, and four and five respectively. The first dorsal metatarsal nerve supplies a branch to the medial side of the first digit; and the most lateral dorsal metatarsal nerve supplies a ramus to the lateral side of the fifth digit. The second intermetatarsal space is invaded by the deep peroneal nerve as described below.

3) The Deep Peroneal (Anterior Tibial) Nerve (E, fig. 20) leaves the common peroneal nerve close to the origin of the superficial peroneal nerve, but passes deeply to follow the anterior tibial vessels. This nerve passes distally along the lateral surface of the interosseus membrane to pass under the annular ligament to appear on the tarsus between the tendons of the extensor digitorum longus and m. tibialis anterior. Muscular rami are given off to neighboring muscles as the nerve passes distally. In the foot the deep peroneal nerve passes deep to the tendons of the m. extensor digitorum longus and follows a dorsal metatarsal artery through the second intermetatarsal space as the dorsal metatarsal nerve II. It bifurcates into two dorsal digital nerves which supply the contiguous sides of the second and third digits.

II. Tibial (Internal Popliteal) Division (Nerve):

The Tibial nerve (D, fig. 20; A, fig. 21) is the larger primary division of the sciatic which, in the proximal third of the thigh, lies caudad to the common peroneal division. At approximately the level of the third trochanter the tibial nerve gives rise to the following:

1) The Nerve to the M. Biceps Femoris Posticus (G, fig. 20) is a slender nerve which leaves the tibial nerve from the caudal side to pass distally within the common sciatic sheath as far as shown in the figure. At this level the nerve passes directly to the mm. biceps femoris posticus and abductor cruis posterior (tenuissimus).

2) The Sural Nerve (B, fig. 20; D, fig. 21) arises from the medial side of the tibial nerve to pass distally within the common sciatic sheath for a variable distance prior to its entrance into the popliteal fossa and then to the shank as described. The sural nerve passes through the fossa to appear superficially as it leaves the posterior border of the "hamstring" muscles. In this superficial position the nerve is accompanied by the superficial sural vessels and continues distad between the medial and lateral heads of the m. gastrocnemius. In the distal third of the shank the sural nerve passes obliquely laterad to the lateral border of the gastrocnemius where the sural nerve gives rise to the following: (i) a lateral cutaneous branch

(F, fig. 21) to the skin along the lateral side of the tarsus and metatarsus; and (ii) a plantar branch (E, fig. 21) which passes mediad under Achilles' tendon to receive an anastomotic branch from the tibial nerve before passing under the tendon of the m. plantaris and continuing to the lateral side of the fifth digit. There are inconsistent anastomotic rami between the plantar branch of the sural nerve and the lateral plantar branch of the tibial nerve (fig. 21).

3) The Nerve to the Lateral Head of the M. Gastrocnemius (I, fig. 20) arises from the cranial side of the tibial nerve at variable levels. This nerve follows the tibial nerve closely, and just proximad of the gastrocnemius muscle the nerve leaves its parent stem to penetrate the lateral head of the muscle as illustrated in the figure.

After giving rise to the branches described above, the tibial nerve continues distad to pass mediad to the common peroneal nerve and traverses the popliteal fossa behind the popliteal vessels to enter the shank between the two heads of the m. gastrocnemius. As the tibial nerve penetrates the m. gastrocnemius, it tends to remain mediad and extends deeply between the medial head of the gastrocnemius and the plantaris muscles. In this deep position the tibial nerve usually gives rise to three branches to the area of the popliteal fossa and the upper third of the shank. These nerves usually appear in a linear formation, and the main stem of each is distributed as follows: the most proximal

FIGURE 21. INNERVATION OF THE PLANTAR SURFACE OF THE HINDPAW

A. Tibial N.

B. Lateral Plantar N.

C. Medial Plantar N.

D. Sural N.

E. Plantar Branch of Sural N.

F. Lateral Cutaneous Branch of Sural N.

G. (Proper) Plantar Digital N. I

H. Plantar Metatarsal N. I (Common Digital N. I)

I. Plantar Metatarsal N. II

J. Plantar Metatarsal N. III

K. Plantar Metatarsal N. IV

L. (Proper) Plantar Digital Nn.

1. Tuber Calcis

2. Achilles Tendon

3. Tendon of M. Plantaris

4. Tendon of M. Flexor Digitorum Brevis

5. Skin

I. First Digit

V. Fifth Digit

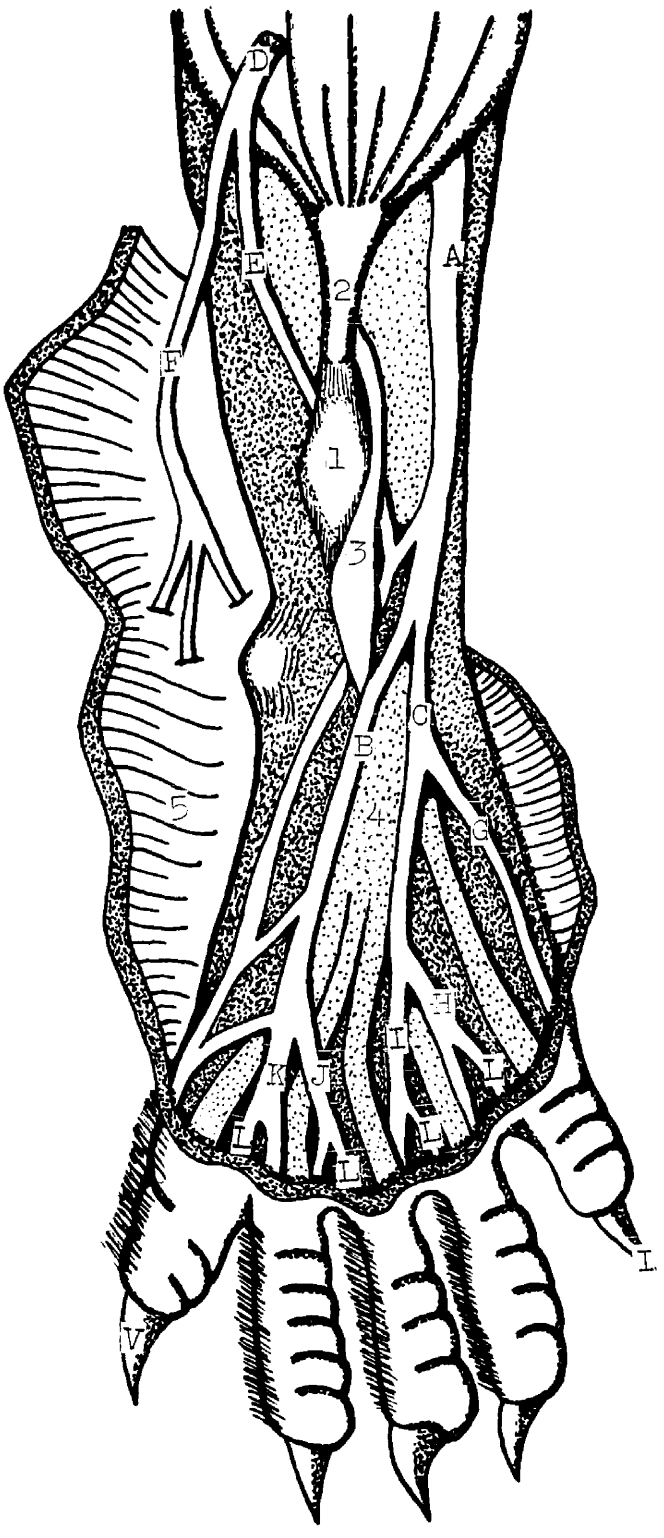
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FIGURE 21. INNERVATION OF THE PLANTAR SURFACE OF THE HINDPAW

A. Tibial N.

B. Lateral Plantar N.

C. Medial Plantar N.

D. Sural N.

E. Plantar Branch of Sural N.

F. Lateral Cutaneous Branch of Sural N.

G. (Proper) Plantar Digital N. I

H. Plantar Metatarsal N. I (Common Digital N. I)

I. Plantar Metatarsal N. II

J. Plantar Metatarsal N. III

K. Plantar Metatarsal N. IV

L. (Proper) Plantar Digital Nn.

1. Tuber Calcis

2. Achilles Tendon

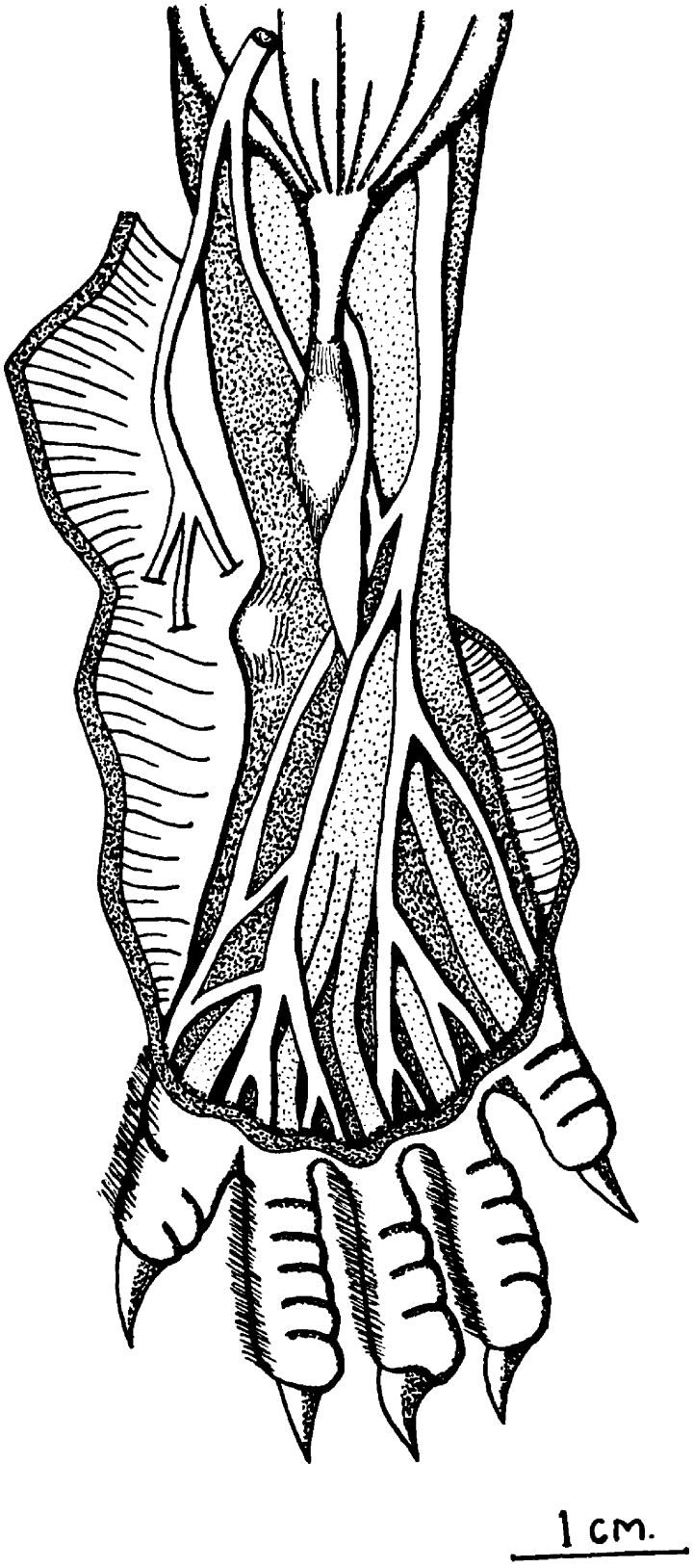
3. Tendon of M. Plantaris

4. Tendon of M. Flexor Digitorum Brevis

5. Skin

I. First Digit

V. Fifth Digit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nerve passes to the medial side of the plantaris muscle; the middle nerve penetrates the popliteus muscle and gives rise to very small inconsistent muscular rami, some of which go to the m. soleus. Others follow the posterior tibial blood vessels to accompany the next nerve described; the third nerve follows the posterior tibial vessels and ramifies to supply the flexor muscles of the digits and the m. posterior tibialis. As described above, the lateral and medial heads of the m. gastrocnemius are supplied by tibial branches which arise independently proximad to the penetration of the m. gastrocnemius by the tibial nerve.

After giving rise to the above branches, the tibial nerve proceeds distally through the shank beneath the anterior border of the medial head of the m. gastrocnemius. As this nerve emerges from beneath the border of the same muscle, the saphenous nerve and vessels cross over it medially as they pass to the dorsum of the foot. The tibial nerve (A, fig. 21) proceeds distally along the posteromedial surface of the distal third of the shank to continue onto the plantar surface of the foot. Shortly beyond the tuber calcis (1, fig. 21) the tibial nerve bifurcates into the following branches:

5) Medial Plantar

6) Lateral Plantar

5) The Medial Plantar Nerve (C, fig. 21) leaves the tibial nerve as shown in the figure. At a variable point

near its origin, the medial plantar nerve gives rise to the plantar digital nerve I (G) to the medial surface of the first digit. The medial plantar nerve then continues toward the second metatarsal area where it bifurcates into plantar metatarsal nerves I (H) and II (I) to intermetatarsal spaces one and two, where they divide into plantar digital nerves (L) to the contiguous sides of digits one and two, and two and three. Deep muscular rami and rami to the pads of the sole are given off at random as the medial plantar nerve proceeds along the course described.

6) The Lateral Plantar Nerve (B, fig. 21) leaves the tibial nerve as shown in the figure. This nerve proceeds diagonally to the fourth metatarsal area where it divides into plantar metatarsal nerves III (J) and IV (K) which follow distally the third and fourth intermetatarsal spaces. Each plantar metatarsal nerve bifurcates to form two plantar digital nerves (L) which, as shown in the figure, supply contiguous sides of digits three and four, and four and five. Deep muscular rami and branches to the pads are given off at random as the lateral plantar nerve follows its course as described. Anastomotic rami connect the lateral plantar and sural nerves as shown in the figure.

The terminology used above for the superficial plantar innervation of the hindpaw is in agreement with that used for the superficial volar innervation of the forepaw. The same discrepancies in nomenclature existing in the literature

with respect to the forepaw innervation, as discussed earlier in detail, prevail in descriptions of the innervation of the hindpaw. The "plantar metatarsal nerves" described above are referred to by some authors as "common plantar digital nerves". The "plantar digital nerves" described above are sometimes referred to as the "proper plantar digital nerves".

E. PUDENDAL PLEXUS

(Figs. 18,19)

As shown in the figures, there is no sharp demarcation between the sacral and pudendal plexuses. The pudendal plexus is formed primarily from the sixth lumbar and the first two sacral levels. In addition to these levels, the second and third sacral, and the upper coccygeal nerves contribute to the posterior caudal trunks as described below. The pudendal plexus is first located on the ventral side of the dorsal wall of the pelvis and makes its exit to the dorsal side of the pelvis mediad to the sciatic nerve as shown in figure 18.

The major nerves which arise from the pudendal plexus, as described below, are the following:

A) Pudendal

B) Posterior Cutaneous N. of the Thigh

C) Posterior Caudal Trunks

A) The Pudendal Nerve (C, fig. 18; H, fig. 19) arises primarily from the first sacral with contributions from the sixth lumbar and the second sacral levels. This nerve leaves the pelvic cavity by accompanying the sciatic and other nerves through the sciatic foramen. On the dorsal side of the rump the nerve remains mediad in position as it passes caudad to give rise to the following branches:

1) Dorsal N. of the Penis

2) Medial Hemorrhoidal

3) Perineal

1) The Dorsal Nerve of the Penis (D, fig. 18) is immediately distinguishable as a separate nerve along the lateral side of the pudendal nerve near its origin as illustrated in figure 19. As this nerve passes from the pelvis to the dorsolateral side of the rump, it lies on the medial side of the pudendal nerve. Here this nerve passes beneath the coccygeal muscles in close association with the medial hemorrhoidal nerve. The dorsal nerve of the penis passes caudoventrad to the root of the penis where it meets its mate and continues distad on the dorsal side of the penis to the glans. In the female this nerve is usually equally as large as that in the male and has a similar origin and course to terminate on the dorsal side of the clitoris.

2) The Medial Hemorrhoidal Nerve arises from the pudendal nerve immediately lateral to the dorsal nerve of the penis. As described previously, on the dorsal side of the pelvis the two nerves pass mediad into the space immediately ventral to the coccygeal muscles. The medial hemorrhoidal nerve then continues caudad to the side of the rectum and ramifies to supply muscles and other structures in the immediate area of the anus.

3) The Perineal Nerve (E, fig. 18) arises from the pudendal nerve on the dorsal side of the pelvis as illustrated in the figure. Frequently it is difficult to separate this nerve near its origin from the two previously described nerves, viz., the dorsal nerve of the penis and the medial hemorrhoidal nerves. The perineal nerve frequently consists of multiple rami throughout its entire length. This nerve passes caudad to distribute numerous cutaneous rami to the area of the anus, perineum, and the base of the tail. In the male there is at least one predominant branch, the posterior scrotal nerve, to the posterior portion of the scrotum. In the female this ramus passes to the posterior portion of the vulva.

B) The Posterior Cutaneous Nerve of the Thigh (B, fig. 18; G, fig. 19) arises from the sixth lumbar and first sacral levels as the medial continuation of the lumbo-sacral trunk (E, fig. 19). In this position near its origin, the posterior cutaneous nerve of the thigh lies between the sciatic and pudendal nerves. This nerve leaves the pelvis through the sciatic foramen and appears on the dorsal side of the pelvis still between the sciatic and pudendal nerves. This nerve passes caudad lateral to the tuberosity of the ischium to distribute: (a) muscular rami primarily to the semitendinosus, semimembranosus, and biceps femoris posticus muscles; and (b) cutaneous rami to the skin and superficial fascia, some of which extend as far distad as the popliteal fossa.

C) The two Posterior Caudal Trunks on either side extend the length of the tail to supply its muscular and cutaneous nerves. Figure 19 illustrates the ventral divisions of the second and third sacral and the most cranial coccygeal nerves contributing to the formation of the ventral trunk (I). The number of coccygeal nerves is inconsistent, but usually six or seven are discernible. The dorsal primary divisions of the respective spinal nerves anastomose to form the dorsal caudal trunk. The ventral and dorsal trunks supply small rami to the muscles and integument of the respective sides of the tail.

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VI. CURRICULUM VITAE

Thomas William Jenkins was born in Adrian, Michigan, in 1922. His early education was obtained in Ohio, where he was graduated from Chaney High School in Youngstown in 1940.

After three years of college at Kent State University, in Ohio, his education was interrupted in 1943, when he began active duty in the United States Navy.

In 1946, after being discharged from the Navy as a Lt.(j.g.), he returned to Kent State University. From that college he received his Bachelor of Science degree in 1947. While at that institution he was an Undergraduate Assistant in the Department of Biology.

In 1950, he received his Master of Science degree with distinction from Michigan State College. He was a Graduate Assistant in the Department of Zoology for a number of years prior to 1952, when he accepted his present position as Instructor in the Department of Anatomy.