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Nervous System of Felis Domestica

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Nervous System of Felis domestica

Embryology of Nervous System

The origin of the central nervous system is found in the thickening of the cell layer along the dorsal median line of the ectoderm - forming the medullary or neural plate at the posterior end, thus the neural plate becomes less distinct, and is identified with the primitive streak. The next stage in developement is the elevation of the margins of the neural plate, and invagination of the center to form the medullary groove. The folds grow laterally and medially, to unite in the mid-dorsal line, forming the neural tube. Gradually mesodermal cells separate the neural tube and surface ectoderm.

When first formed the neural tube is of uniform calibre throughout. But by a process of dilation, constriction, folding, and fusion the anterior half is dilated, and goes for the formation of the fore-brain, mid-brain, hind-brain, and the cranial nerves. The posterior half gives rise to the spinal cord and spinal nerves. While the body is elongating, certain regions in the dorsal portions grow more rapidly than the ventral regions. This results in three flexures: the cephalic,nape, and sacral. The original neural tube is divided by two constrictions into three primary brain vesicles: prosencephalon (fore-brain), mesencephalon (mid-brain), and rhombencephalon (hind-brain). The prosencephalon subdivides into the telencephalon and diencephalon, the rhombencephalon into the metencephalon and mylencephalon (medulla oblongata). (Figures 1,2, and 3).

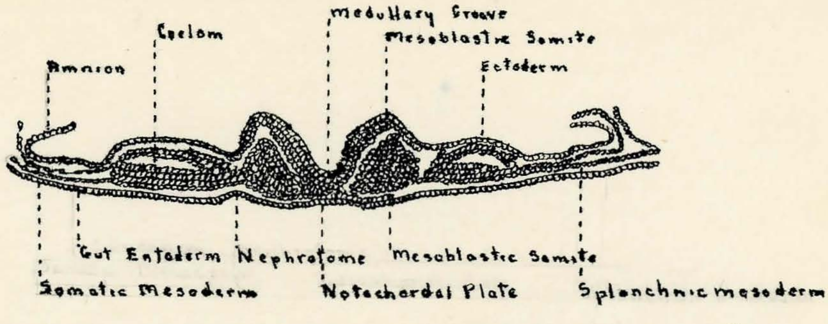

Fig. 1. — Transverse section of a fifteen-day guinea-pig embryo, copulation age [After Harman, pp 97]

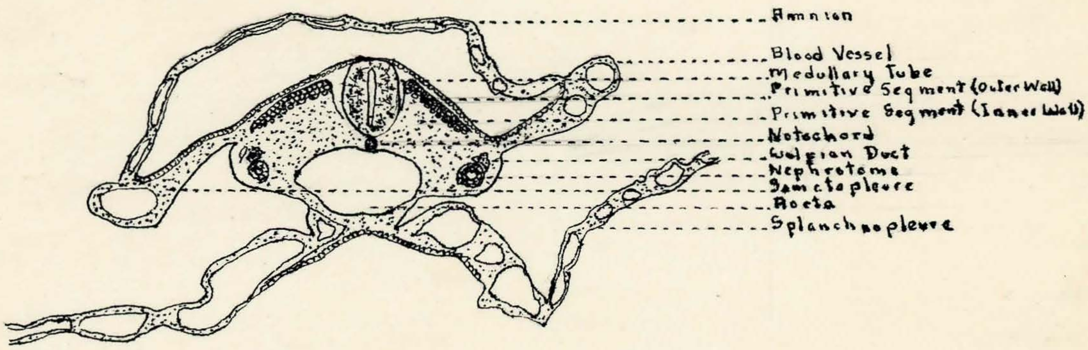

Fig. 2. — Section of a very young cat embryo. (X 50.) [After Harman, pp 101]

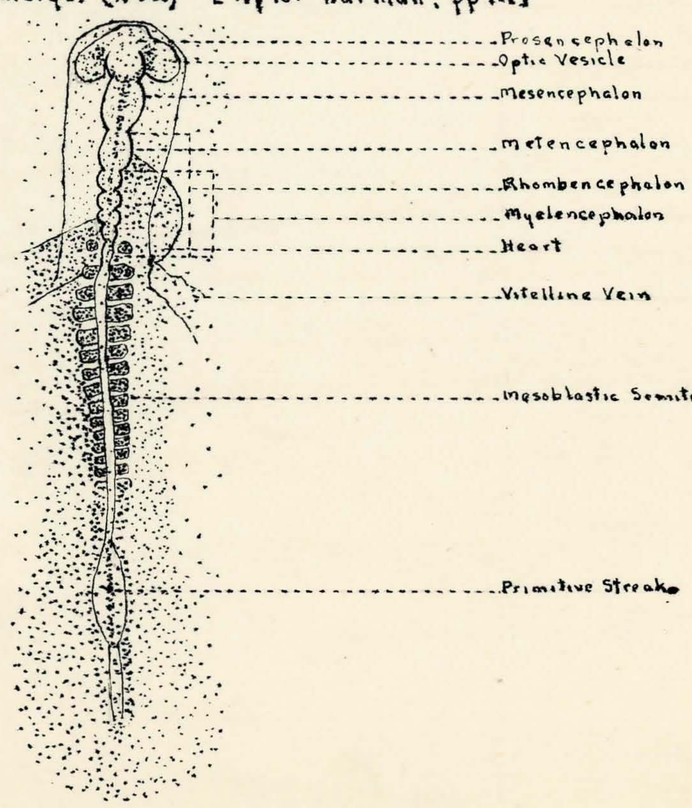

Fig. 3. — Drawing of thirty-six-hour chick, showing neuromeric enlargements in the brain region of the neural tube. [After Harman pp. 207]

After the formation of a syncytium in the spinal cord, a peripheral zone and a zone next to the central canal are recognized. The zone next to the central canal, called the mantle zone, contains cells of two kinds, the ependymal and indifferent. Some of these cells migrate to the periphery of the zone to form a definite layer, the mantle layer. Itis from the cells of this layer that the neuroblasts and neuroglea cells arise. The neuroblasts become nerve cells and the neuroglea supportive cells. The neuroblasts give rise to an axis cylinder and numerous dendrites. Neuroglea fibrils develope from the neuroglea and ependymal cells. Some of the axis cylinders pass directly into the surrounding tissue and from the central nerve roots.

As the medullary canal closes, the ectodermal cells of the neural crest form a wedge at the apex. These cells increase in number and form a mass-the dorsal root ganglion. The neuroblasts send out their processes, some of which penetrate toward the center, while the remaining extend peripherally. The processes from the dorsal root ganglion unite to form the dorsal root of a spinal nerve. The dorsal root soon unites with the ventral root to form the main stem of a spinal nerve.

The sympathetic ganglion cells are derived from cells which migrate from the ganglionic crest. They are first seen as groups of indifferent cells along the ventral branch of the spinal nerve. Later they become segmented, with intertwining strands of nerve fibers. During the process of segmentation thickenings are seen along the cell column, with bundles of fibers extending from them to the viscera. These thickenings are the prevertebral ganglia. Cells migrate along the vagus nerve from the vagus ganglia and walls of the neural tube to form the sympathetic ganglia of the heart, lungs, and anterior part of the alimentary canal. The sympathetic ganglia are derived from cerebral ganglia cells which migrate peripherally.

Nervous System of Felis domestica

Anatomy of Nervous System

The brain is that portion of the central nervous system enclosed within the cranial cavity. It is essentially similar to the spinal cord, varying in the thickness of the walls and number of bends and constrictions. The brain is covered by three meninges - the outermost being the tough duramater, the middle, the arachnoid and the inner, the pia mater. All the spaces between the meninges are filled with the cerebrospinal fluid.

Viewing the brain from the dorsal side, four subdivisions are seen, (see figure 4). Two small olfactory bulbs are at the anterior end. These are extensions of the cerebral hemispheres. Posterior to these are the two cerebral hemispheres. The two are divided by a deep median sagittal fissure. The cerebrum is greatly convoluted, consisting of folds (gyri) and grooves (sulci). At the base of the longitudinal cerebral fissure is situated the corpus callosum (a structure characteristic of the mammalian brain). The large, convoluted mass is seen posterior to the cerebrum and in contact with it is the cerebellum. It consists of a median lobe, the vermis, and two lateral hemispheres. The most caudal portion of the brain is the medulla oblongata, which is partly concealed by the vermis. Beneath the vermis is seen the cavity of the fourth ventricle covered by the chorioid plexus. Lateral to the posterior part of the fourth ventricle may be seen the club-shaped clava, the long tuberculum cuneatum and the posterior peduncle. Due to the projection of the cerebral hemispheres, diencephalom is completely concealed from the dorsal view.

A study of the ventral view of the brain reveals many new elements (Figure 5). The olfactory tracts are seen to extend from the olfactory bulbs to the pyriform lobe. Inclosed between the two pyriform tracts is the diencephalom. The optic chiasma with the projecting optic nerves is at the anterior end. The area between the olfactory tracts and optic chiasma is the anterior perforated substance. Suspended from the tuber cinereum, situated behind the optic chiasma, is the pituitary body. Posterior to the pituitary body is the mammillary body, and posterior to this is the depressed posterior perforated substance from which the oculomotor nerves arise. The cerebral peduncles are seen dorsal to the pyriform lobes.

The pons, consisting of a heavy band of fibers, is located posterior to the posterior perforated substance. It narrows laterally to a cord, the middle peduncle, which goes to the cerebellum. The pons functions as a bridge between the cerellar hemispheres. The trigeminus nerve arises posterior to the middle peduncle. The auditory nerve originates from the area acustica, the facial from the trapezium. The ventral portion of the medulla is grooved by the median ventral fissure. Lateral to the fissure, are found two somatic motor tracts, which emerge posteriorly from the pons. They convey impulses from the cerebral hemispheres to the voluntary muscles.

Examining a median sagittal section of the brain (Figure 6), it is seen that the corpus callosum is enlarged at the anterior and posterior ends, named respectively genu and splenium. The feonix curves ventrally from the corpus callosum. Between the feonix and the corpus callosum is the thin septum pellucidum.

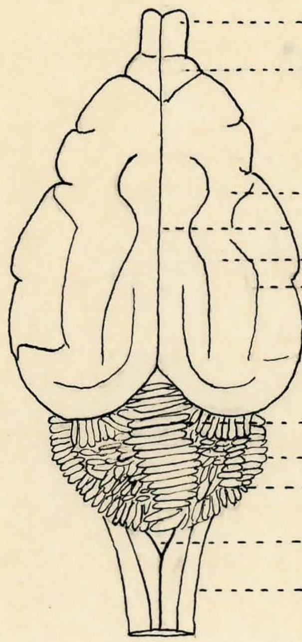

Fig. 4 — Dorsal View of Brain of Felis domestica

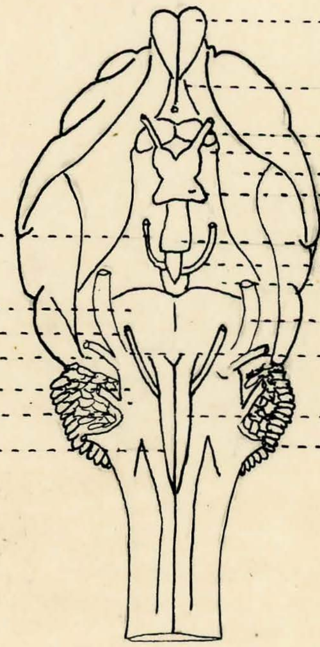

Fig. 5 — Ventral View of Brain of Felis domestica

The cavities of the cerebral hemispheres are the lateral ventricles. The two lateral ventricles constitute the first and second ventricles of the brain. At the point where the fornix disappears is seen the anterior commissure. The cavity of the diencephalom is the third ventricle. The diencephalom consists of three parts, a dorsal epithalamus, a ventral hypothalamus and a central thalamus. The aqueduct connects the third ventricle with the fourth ventricle of the medulla. The floor of the midbrain below the aqueduct is the tegmentum.

The sense organs of the head are the eyes, the nose, and the ears. The ear consists of three parts,the external, middle and internal ear. The external ear consists of the auricle and the external auditory meatus. Across the terminal of the meatus is stretched the tympanic membrane, with the malleus attached to its internal surface. The middle ear extends from the membrane to the fenestra cochlea and fenestra vestibuli. It contains the three bones of the ear. The chorda tympani nerve, a branch of the facial, supplies the eardrum. The inner ear is contained within the petrous bone. Branches of the auditory nerve are distributed in the membrane lining its cavities. The labyrinth contains the cochlea and three semicircular canals.

The nasal cavities are short and divided into right and left fossae by the septum. The cribriform plate forms the dorsal posterior wall of the fossa. Against this plate abut the olfactory bulbs of the brain. From the lining membrane of the ethmioid labyrinth, the fibers of the olfactory nerves arise, pass through the cribriform plate to the olfactory bulbs.

The eyeball is approximately spherical, with the optic nerve entering it at the center of the caudal half. The transparent cornea covers the free surface of the eye, the opaque sclera the remainder. The cornea is covered externally by the conjunctiva. The second coat of the eye is formed by the choroid and iris. Certain areas of the choroid are equipped with a layer of cells containing crystals and giving it a brilliant color and forming the tapetum. It is this layer which causes the peculiar luster to the cat's eyes in the dark. The iris is perforated by an opening, the pupil. The inner coat of the eye is formed by the retina. The blind spot near the center of the retina, is the entrance of the optic nerve. The eye is divided into an anterior chamber containing the acqueous humor, and a posterior chamber containing the vitreous humor.

There are eleven muscles within the orbit. The livater palpebrae superioris is connected with the upper eye lid, the remaining ten with the eyeball. The four larger straight muscles are the recti muscles, the four smaller straight muscles the retractor oculi. The two oblique muscles are the inferior and superior oblique muscles. A branch of the oculomoter nerve innervates the inferior oblique. A zygomatic branch of the maxillary nerve passes to the lower eyelid, while a lacrimal branch of the same nerve goes to the lacrimal gland. The long ciliary branch of the ophthalmic branch of the trigeminus accompanies the optic nerve into the eyeball. The ciliary ganglion of the sympathetic is near this. The main trunk of the oculomotor gives off branches to the retractor bulbi and superior rectus. The ethmoidal nerve, a branch of the opthalmic, passes into the nasal cavity, and another branch of the opthalmic, the infratrochliar nerve goes to the anterior part of the upper eyelid. The frontal branch of the ophthalmic innervates the upper eyelid. The superior oblique muscle is innervated by the trochliar nerve.

Up to this point, scant attention has been paid to the origin and distribution of the cranial nerves. Because of the complex nature of this study, it is necessary to present it in a tabular form to derive the maximum clarity.

Cranial Nerve Summary[1]

Nerve	Origin	Exit	Chief Branches	Distribution
I Olfactory	Olfactory Bulb	Foramina of cribiform plate		Olfactory mucosa
II Optic	Optic Chiasma	Optic foramen		Retina
III Oculomotor	Cerebral Peduncle	Orbital Fissure		Levator palpebra all recti muscles except lateral; retractor oculi; motor branch to ciliary ganglium, inferior oblique.
IV Trochlear	Anterior medullary velum	Orbital fissure		Superior oblique
V Triginimal	Pons	Orbital fissure	Ophthalmic 1. Frontal 2. Infratrochlear 3. Ettimoidal 4. Long ciliary	1. Integument of upper eyelid and surrounding region. 2. Integument of lower eyelid and surrounding region. 3. Mucose of nose 4. Eyeball

1. Taken from <u>Anatomy of the Cat</u> by Jacob Reighard and H.S. Jennings. Henry Holt and Company, 1935 Summary IV. pp. 445,446,447.

Nerve	Origin	Exit	Chief Branches	Distribution
		Foramen rotundum	Maxillary	
			1.Lachrymal	Lachrymal gland; integument between eye and external ear.
			2.Zygomatic	Integument over zygomatic arch.
			3.Infraorbital	Integument over upper lip and side of nose; teeth of upper jaw.
			4.Sphenopalatine	
			a.Greater palatine	Hard palate
			b.Branches to sphenopalatine ganglion	Lesser palatine to soft palate; posterior nasal to nasal mucosa.
		Foramen ovale	Mandibular	
			1.Auriculo-temporal	
			a.Auricular	Integument of external ear.
			b.Temporal	Temporalis muscle and integument over zygoma.
			2.Deep Temporal	Temporalis muscle
			3.Massetericus	Masseter muscle
			4.Pterygoidius	External and internal pterygoid muscles; tensor tympani muscle.
			5.Buccinatorius	Mucosa of mouth and lips; masseter muscle.
			6.Inferior Alveolar	
			a.Mylohyoid	Mylohyoid and digastric muscles.
			b.Inferior dental	teeth of mandibles
			c.Mental	Integument of lower jaw and mucosa of lower lip.
			7.Lingual	Mucosa of tongue and pharynx.
VI Abducens	Pons	Orbital fissure		Lateral Rectus muscle

Nervw	Origin	Exit	Chief Branches	Distribution
VII Facial	Pons	Internal Auditory Meatus	1.Superficial petrosal	To sphenopalatine ganglion
			2.Chorda Tympani	To mucosa of tongue
			3.Posterior auricular	External ear muscles and to inner surface of external ear
			4.Dorsal Ramus	
			a.Temporal	Superficial muscles
			b.Zygomatic	" "
			c.Branch to submental muscle	Submental muscle
			5.Ventral Ramus	
			a.Superior buccal	Muscles of upper lip
			b.Inferior buccal	Muscles of lower lip and chin
			c.Branch to Stylohoid muscle	Stylohyoid Muscle
			6.Branch to Stapedius muscle, while nerve is in facial canal	Stapedius muscle
VIII Acoustic	Junction of Pons and Medulla	Internal Auditory Meatus	1.Cochlear Portion	Cochlea
			2.Vestibular Portion	Vestibule and semicircular canals
IX Glossopharyn-geal	Medulla	Jugular Foramen		Stylopharyngeal muscle; muscles and mucosa of pharynx through pharyngeal plexus
X Vagus	Medulla	Jugular Foramen	1.Auricular	External ear
			2.Pharyngeal	Pharyngeal muscles and cranial end of esophagus
			3.Superior laryngeal	mucosa of larynx
			4.Cardiac	Heart
			5.Inferior laryngeal	muscles of larynx

Nerve	Origin	Exit	Chief Branches	Distribution
			6.Pulminary	Lungs
			7.Dorsal and ventral branches in esophagus through diaphragm	Abdominal viscera
XI Accessory	Bulbar from medulla: spinal from spinal cord	Jugular Foramen		cleidomastoid sternomastoid and trapizius muscles
XII Hypoglossus	Medulla	Hypoglossal canal		Hyoid and tongue muscles

Since the brain and spinal cord both arise from a common origin and serve essentially the same functions - it is only natural that their structures would be basically similar. The spinal cord is situated within the vertebral canal. It is covered by the continuation of the cranial meninges - the outer dura mater, the thin arachnoid, and inner pia mater. The spaces between these are filled with cerebro-spinal fluid. Unlike the brain, the gray matter is centrally located, surrounded by white matter.

The surface of the cord has a number of longitudinal sulci and fissures. The two most prominent are the anterior median fissure in the median ventral line, and the posterior median sulcus on the dorsal median line. These divide the cord into halves. Each half has less noticable anterior and posterior lateral sulci. The cord has cervical and lumbar enlargemenls.

The spinal nerves arise from the spinal cord by means of a dorsal root from the dorsalateral region of the root, and a

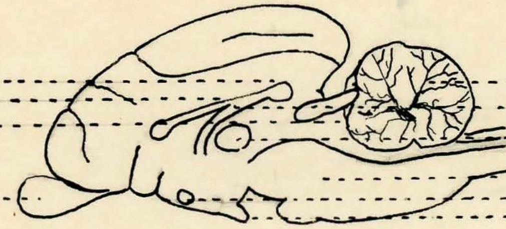

Fig. 6 — Median Sagittal Section of the Brain of Felis domestica

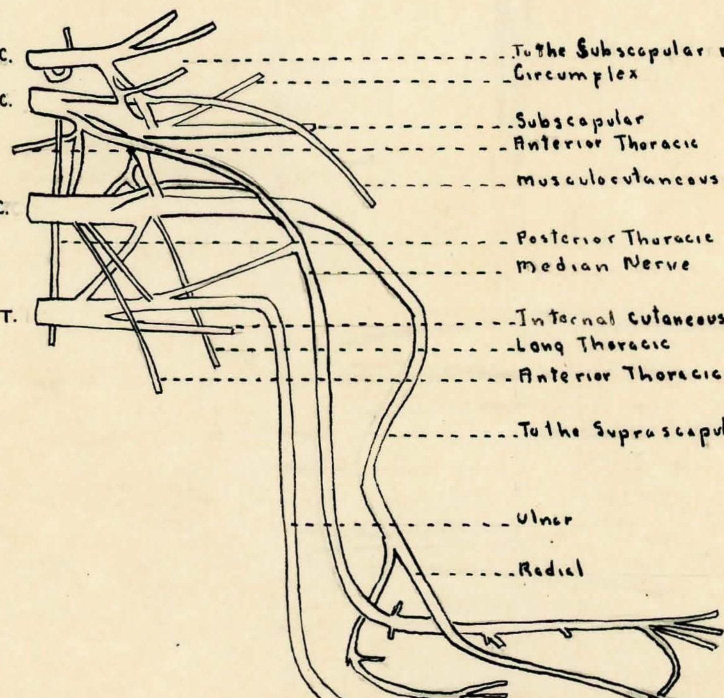

Fig. 7 — Ventral Aspect of the Brachial Plexus and Chief Nerves of the Arm
[After Davison, pp. 251]

ventral root from the foramen ventrolateral region of the root (Figure 9). The dorsal root carries sensory fibers only, while the ventral root carries motor fibers. Near the intervertebral foramen the dorsal root bears a spinal ganglion. Beyond the ganglion the two roots unite, pass through the intervertebral foramen and divide into the dorsal and ventral rami and communicating rami. The dorsal ramus innervates the epaxial muscles and adjacent skin, the ventral ramus innervates the hypaxial muscle and adjacent skin, and the communicating rami go to the sympathetic system.

There are thirty-eight pairs of spinal nerves in the cat. Eight are cervical, thirteen thoracic, seven lumbar, three sacral and seven or eight caudal. The ventral rami of the first four cervicle nerves loosely unite with one another to form the cervical plexus. The last four cervical nerves, and the first thoracic unite with each other to form the brachial plexus. The formation of this plexus is due to the union of the nerves by means of strong, connecting ansae. The plexus lies in axilla, and all the nerves pass laterally in front of the first rib. The branches supply the arm, shoulder, breast, and diaphragm. The chief nerve of the brachial plexus (Figure 7) are as follows;

1. Phrenic nerve - arises from fifth and sixth, goes to diaphragm.
2. Suprascapular - arises from sixth, passes between supraspinatus and subscapular muscle to supply supraspinatus and infraspinatus.
3. Subscapular (3)
   (a) First nerve arises from sixth cervical, goes to subscapular muscle.
   (b) Second nerve arises from seventh cervical, goes to teres major.

(c) Third nerve arises from seventh and eighth cervical, goes to latissimus dorsi.

4. Ventral thoracic -

(a) First nerve arises from seventh cervical, goes to pectoral muscles.

(b) Second nerve arises from eighth cervical and first Thoracic, goes to pectoral muscles.

5. Axillary - arises from seventh cervical, supplies deltoid muscle.

6. Dorsal thoracic - arises from seventh cervical, goes caudally along serratus ventralis muscle.

7. Musculocutaneous - arises from sixth and seventh cervical, goes to biceps muscles and skin of forearm.

8. Radial - arises from seventh and eighth cervical and first thoracic, supplies muscles of forelimb.

9. Median - seventh and eighth cervical and first thoracic - limb distal to elbow.

10. Ulnar - first thoracic - limb distal to the elbow.

11. Medial cutaneous - first thoracic - to skin of forearm.

The ventral rami of the remaining seven thoracic nerves pass laterally as intercostal nerves, while the dorsal rami supply the epaxial muscles. The ventral rami of the last four lumbar nerves from the lumbar plexus, as do the ventral rami of the sacral nerves a sacral plexus. These plexi are interconnected by means of short branches to form the the lumbo-sacral plexi. The nerves of the lumbosacral plexus (Figure 8) are as follows:

1. Lateral cutaneous - arises from fourth and fifth lumbar, goes to thigh.

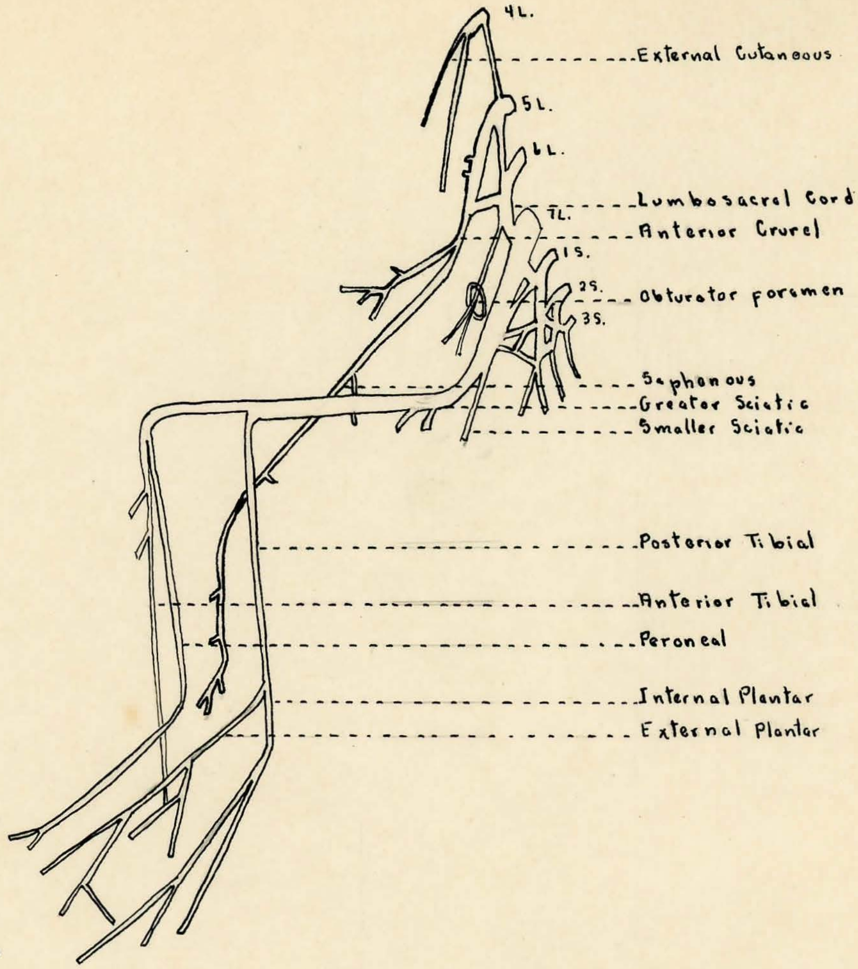

Fig. 8 – Ventral Aspect of the Nerves of Hind-Limb [After Davison pp. 261]

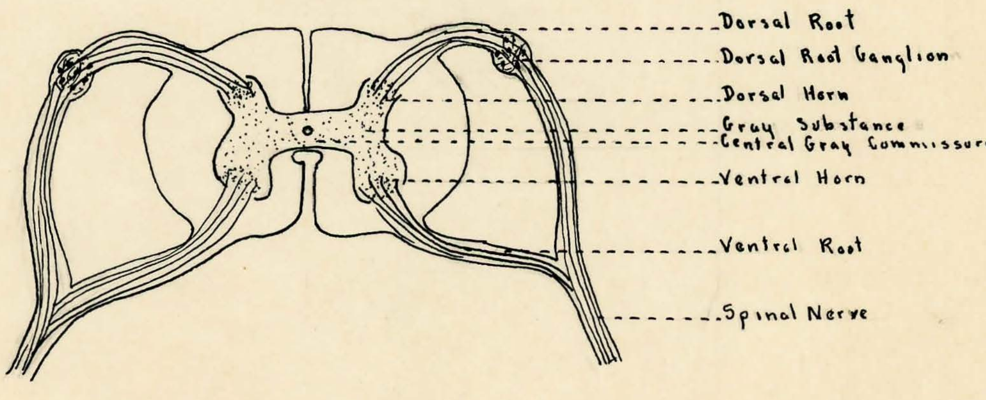

Fig. 9 – Diagramatic Sketch of Spinal Cord to Show Origin of Spinal Nerves

2. Genito Femoral - arises from fourth lumbar, thigh and abdominal wall.

3. Femoral - arises from fifth and sixth lumbar, innervates muscles of thighs and then goes to shank and foot as saphenous nerve.

4. Obturator - arises from sixth and seventh lumbar, to gracilis and other muscles.

5. Sciatic - sixth and seventh lumbar, first and second sacral, gives use to

   (a) gluteal nerves to glutial muscles

   (b) branches to thigh muscles

   (c) peroneal - gives rise to small muscle branches, then divides into deep and superficial peroneal nerves.

   (d) tibial, gives rise to small muscle branches, then divides into medial and lateral plantar nerves.

6. Inferior haemorrhoidal - first, second and third - to bladder and rectum.

7. Pudental nerve - second and third sacral - rectum and urogenital organs.

8. Posterior cutaneous - second and third sacral - to biceps femoris.

The caudal spinal nerves perform like the other spinal nerves. They give off dorsal rami that innervate the dorsal muscles of the tail, and ventral rami that innervate the muscles and integuments of the ventral side of the tail. The ventral rami are connected with one another and the third sacral nerve by a longitudinal cord.

The sympathetic nervous system consists of a pair of nerve cords extending from the base of the skull to the tail, a number of ganglia and branches to the viscera, and fibers to the musclar walls of the blood vessels. The sympathetic nervous system supplies all the non-striated muscles of the body, and the heart.

The sympathetic trunks lie on either side of the bodies of the vertebra from the base of the skull to the tail. They consist of a series of ganglia united by nerve cords. The ganglia are connected to the thoracic and first four lumbar spinal nerves by white and gray rami communicantes, and to the remaining by gray communicantes alone.

Near the angle of the mandible is situated the superior cervical ganglion, which is the beginning of the sympathetic nerve cord. From this point the sympathetic nerve cord passes caudally. The vagus and the sympathetic are bound in a common sheath beside the common carotid in the aurical region. At the first rib, there is the middle cervical ganglion, which gives two cords to the inferior cervical ganglion, posterior to the first rib. The sympathetic cord, in the cervical region, gives off numerous branches which form the carotid plexus, unites with the eight posterior cranial nerves and first spinal nerve. Branches of the inferior cervical ganglion go to the vagus, to the brachial plexus and to the heart forming the cardiac plexus. The sympathetic cord then continues along the dorsal thoracic wall, having a ganglion at every vertebral wall. These ganglia give off a branch to the corresponding spinal nerve.

The three great sympathetic plexi are the epigastric, the hypogastric, and the cardiac. The epigastric plexus lies dorsal to the stomach, to which it sends many branches. This plexus receives the great splanchnic, and lesser splanchnic nerves, and branches from the tenth cranial nerve. The celiac is the largest ganglion of the epigastric plexus. The solar and its allied plexi send nerves to the diaphragm, suprarenal bodies, stomach, kidneys, ureters, testes or ovaries, uterus, liver, gall-bladder, spleen, pancreas, intestines, and the associated blood vessels. The hypogastric plexus is ventral to the two posterior lumbar vertebrae. It is formed by branches from the solar plexus and sympathetic cords. It supplies all the organs and blood vessels of the pelvis. The cardiac plexus has been mentioned. There is one and perhaps two median ganglia in the sacral region known as the ganglion impar.

Nervous System of Felis domestica

Histology of Nervous System

Nervous tissue is composed of nerve cells, nerve fibers, and supporting neuroglia. Irritability and conductivity are the predominant properties of nervous tissue, The nerve cell, neuron, is the anatomical unit of structure. The neuron includes the cell body, its dendrones and proximal part of its axon (Figure 10). The distal part of the axon forms the nerve fiber. Nerve cells are found in the gray matter, central system, peripheral ganglia of cerebrospinal division, and in the sympathetic ganglia.

The cytoplasm of the neuron is finely granular, and is divisible into a readily stainable substance, the stainable substance of Nissl, and a homogeneous substance which is not so easily stained. Flake-like granules of irregular size and shape are found in the cytoplasm. These are known as Nissl's or tigroid substance. The nucleus is large and excentrically situated. The nuclear membrane is highly chromatic, while the contents within the nuclear membrane are noticably lacking in chromatin.

Arising from the cell body as a broad stem, the dendron divides into branches that can be traced for some distance. The structure of the dendron is similar to that of the cell body. At the ends, the dendrons arborize. The filaments of this arborization are frequently in contiguous relation with the axons of other neurons. This is called a synapse. Dendrons tranmit impluses to the neuron, that is they are cellulipital processes. Each neuron usually possesses one axon and several dendrons.

Neurons may be classified into uni-, bi-, and multipolar cells according to the number of dendrons.

Unlike the dendrons the axon is long, slender and does not arborize near the neuron. It arises from a clear area, axon hillock, in the neuron. Both the axon hillock and axon are deficient in chromophilic granules. The axon consists of axon fibrils embodied in axoplasm. Some distance from the cell body, the axon gives rise to small collaterals. The collaterals and axon arborize. This area is in contiguous relation with dendritic arborization, and forms a synapse. The axon transmits impluses away from the neuron, i.e. is a cellulifugal process.

A nerve fiber is an axon with its enveloping sheaths. Nerve fibers are classified into myelinated nerve fibers with or without a neurilemma, and unmyelinated nerve fibers with or without a neurilemma. Myelinated nerve fibers with a neurilemma, consist of a central axis cylinder covered by a medullary sheath and a neurilemma (Figure 11). The axis cylinder is made up of fine fibrils. These fibrils are not well understood but may be a continuation of the neurofibrillar network of the cell body. The medullary sheath invests the axis cylinder, and serves as a nutritive and insulating agent. At regular intervals medullary sheath breaks off, and the neurilemma dips in, and contacts the axis cylinder. These constructions are known as the nodes of Ranvier. They divide the nerve fibers into internodal segments. The neurilemma is the outermost sheath. It is a very delicate membrane. In each internode, the oval nucleus of the neurilemma may be seen attached to the under side.

The remaining three types of fibers have essentially the same histological make-up, varying only in the presence or absence of enclosing sheaths . The myelinated nerve fibers with a neurilemma compose nearly all the nerve fibers of the cerebrospinal nerve trunks and ganglia, and some of the sympathetic nerves. The myelinated nerve fibers without a neurilemma compose the white matter of the central nervous system. The unmyelinated nerve fibers with a neurilemma make up most of the fibers of the sympathetic nervous system. The unsheathed axis cylinders are found in the proximal end of the axon in the gray matter, and distal end of the axon before its arborization.

The supporting element of nervous tissue is supplied by the neuroglia, which consists of the glia cells and glia fibers. The glia cells are divided into ependyma cells and astrocytes. The ependyma are nucleated columnar cells, which in embryonic life are ciliated. The astrocytes have a number of processes. On the basis of these processes, astrocytes are classified into long-rayed astocytes, having shorter and thicker processes. The glia fibers are filiform fibrils which occur densely around the glia cells.

The surface of the cerebral hemispheres consists of a sheet of gray matter which varys in thickness. The nerve cells and fibers are the principal components of the cortex. When a perpendicular section through the cortex is studied, six layers are noted. They are: (1) stratum zonale, (2) outer granular layer, (3) external pyramidal layer, (4) inner granule layer,

(5) internal pyramidal layer, and (6) layer of polymorphic cells. The stratum zonale has few nerve cells, some of which are Cajal's cells. The outer granular layer contains many small triangular or pyramidal shaped cells. The external pyramidal layer contains larger pyramidal cells. Inner granule layer is a narrow layer containing stellate cells. The internal pyramidal layer contains the most distinctive cells of the cerebral cortex. These pyramidal cells have a conical body, with a long tapering dendrite, apical process, extending to the periphery, and a delicate axon that extends centrally and acquires a medullary sheath. Several less important lateral dendrites also arise from the cell body. The layer of polymorphic cells contains many small cells varying greatly in size and shape. The nerve fibers of the cortex are radially disposed bundles which become less distinct as they traverse the cortex and finally disappear in the region of the large pyramidal cells.

The surface of the cerebellum is likewise covered with gray matter which incloses the medullary layer or gray matter (Figure 12). The gray matter of the cerebellar cortex is divided into two strata, the outer molecular and inner granule layer. The molecular layer is composed of three types of cells: the Purkinje cells, basket cells, and the superficial small cortical cells. The Purkinje cells are the most distinctive cells of the cerebellum, and occupy the deepest part of the molecular layer. They have flask-shaped bodies, with a single stout dendrite to the surface, and a basal axon to the granular area. The granule layer contains two varieties of cells, the granule cells and

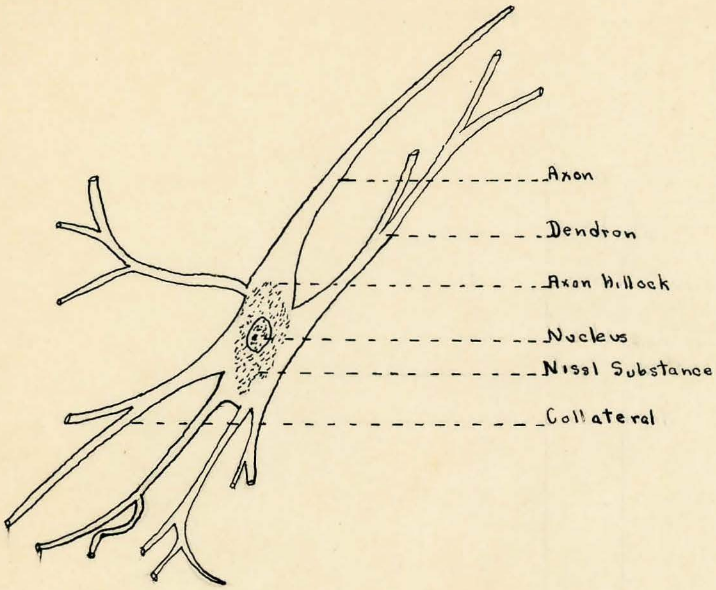

Fig. 10 - Isolated Nerve Cell

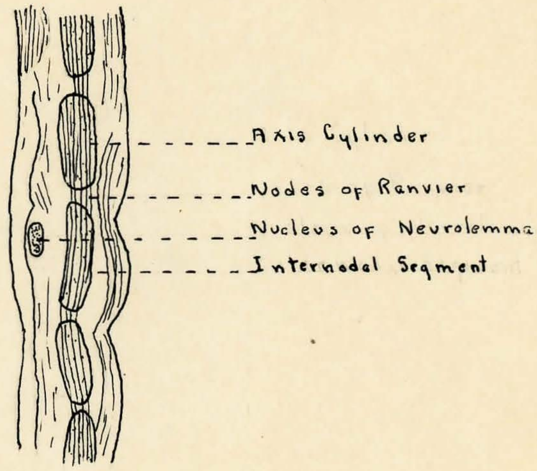

Fig. 11 - medullated Nerve Fiber

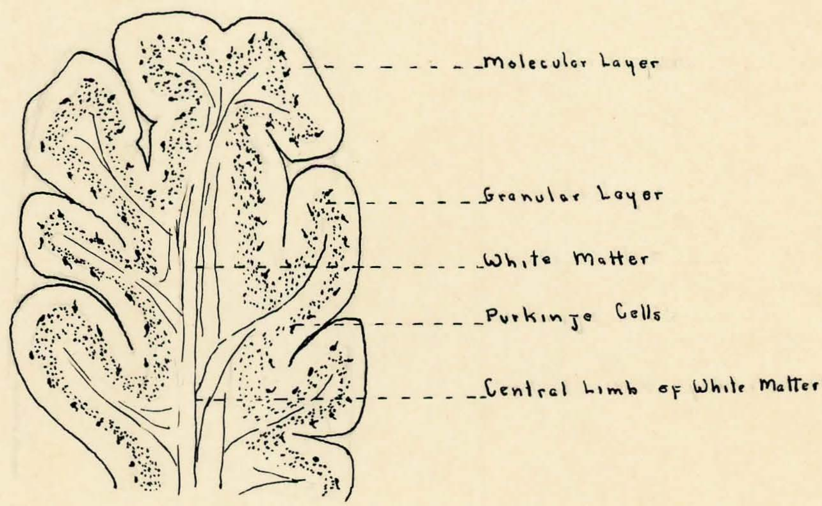

Fig. 12 - Section through Cerebellar Follium

large stéllate cells. The granule cells are very small and numerous, having three to six short radiating dendrites and axons that end without arborization. The large stellate cell has an irregularly formed cell-body with several richly branching dendrites, and an axon which arborizes to an unusual extent and complexity. The chief varities of nerve fibers in the cerebellar cortex are the axones of Purkinje, moss fibers to the granule layer and climbing fibers to the molecular layer.

Due to the complexity of the fiber tracts in the medulla, and the relative absence of important elements in the pons and mid-brain, it is unnecessary to consider them in a paper of this type. Several pointa, however, should be mentioned. The medulla contains myelinated fibers of three types: climbing fibers, mossy fibers, and axon of the Purkinje cells. Both cortex and medulla contain an abundance of neuroglia. The astrocytes of the medulla are of the long-rayed type.

The spinal cord consists of a centrally located mass of gray matter in the form of an H, and a surrounding layer of myelinated nerve fibers, the white matter. Thus it is seen the white and gray matters have become reversed in position. The gray matter is composed of two lateral portions united by the gray commissures. The lateral portions are divided into a dorsal horn and a broader ventral horn. The caputs of the horns are united by the intermediate zone of Golgi by means of a cervix cornu. The cells of the ventral horn give rise to axons, which unite into bundles, and pass ventrally to form the ventral nerve roots. The dorsal horns receive incoming fibers from the dorsal nerve roots. The dorsal roots enter by the dorsolateral sulcus.(Fig.13)

The gray matter of the spinal cord is made up of nerve cells, unmyelinated fibers, axons, dendrons, collaterals, and neuroglia. Within the commisure is found the central canal, a continuation of the ventricles of the brain. It is lined by columnar cells which may be ciliated, and is surrounded by a gelatinous tissue, the substantia gelatinosa centralis. The most important cells of the ventral cornu are the motor radicular cells, whose axons form the axis cylinders of the efferent root-fibers of the spinal nerves going to the voluntary striated muscles. The nerve-cells of the ventral cornu are collected in rather definite groups. The nerve cells of the dorsal cornu are not as large nor as regularly distributed as those of the ventral cornu. In one locality alone, they are collected in a distinct group to form the cell-column of Clarke. The structure of the neuroglar elements follow that which has already been described. However, the fibrils in the gray matter is more compact than in the white matter, and is somewhat denser towards the periphery. The nerve fibers of the gray matter are seen to traverse the gray matter in all directions, originate in the same, different,or even remote levels.

The outer white matter decreases in thickness as the cord nears the caudal portion. It is divided into lateral halves by the dorsal median septem extending to the central gray commissure, and the ventral median sulcus which does not penitrate all the way to the gray commissure, but leaves a ventral white commissure. The white of each lateral half is further divided into a ventral, lateral, and dorsal column. Each column is again sub-divided by neurogliar septa. The most constant of these septa, the paramedian septum, subdivides the dorsal column into the columns of Goll and Burdach. In the ventral white column there are two chief fiber tracts: the narrow median anterior pyramidal tract and the more lateral larger anterior ground bundle. In the lateral column four main tracts may be distinguished: the upper crossed pyramidal tract, the middle direct cerebellar tract, a lower Gowers column, and a large medial lateral ground bundle. The larger blood vessels originate from the vessels of the pia matter, and are distributed to the white matter, also supplying the gray.

Because there is a varying number of fibers given off from the spinal cord at various levels, there is a considerable difference in the size at its several levels. Based on this peculiarity, caudal, sacral, lumbar, thoracic and cervical regions are recognized. Each level has its own morpholigical characteristics.

In the sacral region, the white matter layer is very thin, The ventral and dorsal horns are short and thick. The substantia gelatinosa Rolandi is of considerable volume. The cord is small and nearly circular. In the lumbar region there is a considerable enlargement of the gray substance. This is due to the number of motor fibers that enter the lumbar nerve trunks to the lower limbs. The dorsomedial column is quite large. The ventral and dorsal gray horns are long and thick. The cell groups of the ventral horns are the ventromedial, ventrolateral, and dorsolateral. The gray matter of the thoracic region is reduced to a comparatively small central mass, while the white matter is quite voluminous. This is because of the number of nerve fibers coming to or going from the lumbar enlargement. At the base of each dorsal horn there is a distinct cell group of oval form, - the cell column of Clarke. The ventral horns are short and narrow. The lower half of the cervical region is enlarged. The spinal cord assumes a flattened shape, being shorter in the ventro-dorsal diameter. The dorsal horns are long and slender, while the ventral horns are long and broad. The upper half of the cervical region resembles the thoracic, differing only in the larger size. The larger size is due to the increase in the white matter of the dorsal and lateral columns.

In order to round out the histological concept of the nervous system it is necessary to study several more elements: the ganglia, sympathetic system, and peripheral nerve terminations. A ganglion is a group of nerve cells occuring in the course of a peripheral nerve trunk. The essential element of structure are the nerve cells, nerve fibers, and a supporting framework of dense fibro-elastic connective tissue (Figure 14). Most of the mammalian nerve cells are unipolar in the cerebro-spinal ganglia, and multipolar in the sympathetic, Except for the ganglia of the acoustic nerve, the nerve cells of all ganglia are surrounded by a capsule of flat epithelioid cells. This capsule invests the cells and its processes and is continuous with the neurilemmma, but is separated from the cell by a narrow margin. Ganglionic neurons possess a large vesicular nucleus with a distinct nucleolus.

As has been previously stated, the sympathetic nervous system consists essentially of three sets of ganglia; sympathetic cords,prevertebral plexuses and visceral plexuses. The ganglia of the sympathetic trunks are segmentally arranged and interconnected by plexi of unmyelinated fibers. The prevertable plexi (cardiac, celiac, etc.) contain fewer and smaller cells with a preponderance of fibers. The visceral plexi have even smaller and fewer cells, with a less dense fiber network. Two types of cells are recognized in the sympathetic ganglia, small multipolar fusiform cells , and larger spheroidal neurons, the former are motor neurons, while the latter are sensory neurons. The sympathetic ganglia differ from the cerebrospinal ganglia in that the first has more unmyelinated nerve fibers, while the second has more myelinated nerve fibers.

All peripheral nerve fibers end either as terminal fibrils or in relation to an end organ. The nerve endings in epithelium may be end-fibrils, tactile cells, or neuro-epithelium of the ear, eye, and taste buds. End organs of connective tissue may terminate in touch corpuscles of Meissner, Ruffini's end organs, end bulbs of Krause, Pacinian corpuscles, motor end-plates, etc.. (Figure 15). The function of these bodies is to change stimuli into nerve impluses, or nerve impluses into cell stimuli, according to the nature of the nerve fibers stimulated. Recognition of the existance of these peripheral nerve terminations is all that can be given, for a study of them is without the scope of this paper.

1.A ganglion differs from a plexus in that it has many more cells.

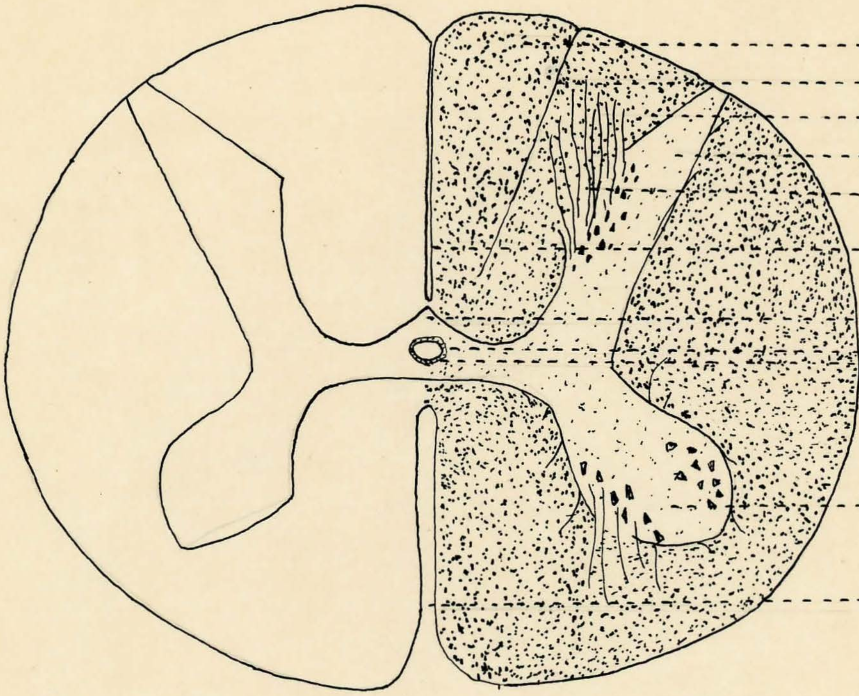

Fig. 13 - Cross Section of Spinal Cord

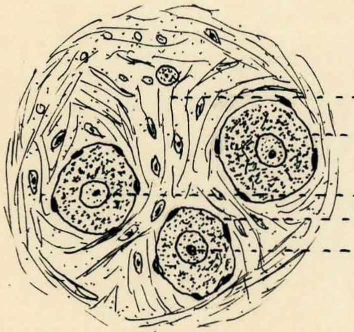

Fig. 14 - Section of Spinal Ganglion

Fig. 15 — Longitudinal Section of Pacinian Corrpuscle

Summary

The nervous system is derived from ectoderm. It is subdivided into central, peripheral, and sympathetic nervous systems. The central nervous system includes the brain and spinal cord, the peripheral system the cranial and spinal nerves, the sympathetic cords, ganglia, and nerves.

There are three primary vesicles; prosencephalon, mesencephalon, and rhombencephalon. The prosencephalon subdivides into telencephalon and diencephalon, the rhombencephalon into the metencephalon and myelencephalon. The telencephalon differentiates into olfactory bulbs, olfactory tracts, olfactory lobes, and cerebral hemispheres. The diencephalon differentiates into hypothalamus, thalamus, and epithalamus. The mesencephalon subdivides into optic lobes, egmentum and cerebral peduncles. The mylencephalon becomes the medulla oblongata. There are twelve cranial nerves. The gray matter is peripheral in location; the white is centrally located.

The spinal cord consists of an outer white matter and inner gray matter. From it arises the thirty-eight pairs of spinal nerves by means of a sensory dorsal and motor ventral root. The spinal nerve divides into dorsal, ventral, and communicating rami. The first remus goes to the epaxial muscles, and second to the viscera and limbs by means of plexi, and the third connects with the sympathetic system.

The sympathetic nervous system consists of essentially three sets of ganglia-sympathetic cords, prevertebral plexi, and visceral plexi. These are connected with the spinal and cranial nerves, and with the visceral, gland, blood vessels, etc..

Nervous tissue is composed of nerve cells, nerve fibers, and supporting neuroglia. Irritability and conductivity are the properties of nervous tissue. The neuron is the anatomical unit of structure.

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