The Canine Nervous System: Writing Assignment

Functions of the Nervous System:

The nervous system has three basic functions. They are sensory, integrative and motor.

The sensory function senses changes or stimuli outside and within the body. For example, the eyes sense changes in light and the ear responds to sound waves.

The integrative function processes information received from the sense organs. The impulses from these organs are analysed and stored as memory, and an appropriate response is initiated.

The motor function responds to stimuli that cause muscles to contract or glands to secrete.

The Neuron:

All nervous tissue is made up of nerve cells or neurons that transmit nerve impulses. A neuron has a cell body containing a nucleus, one or more branching filaments called dendrites which conduct nerve impulses towards the cell body and one long fiber called an axon that carries impulses away. Axons are surrounded with a fatty material called myelin.

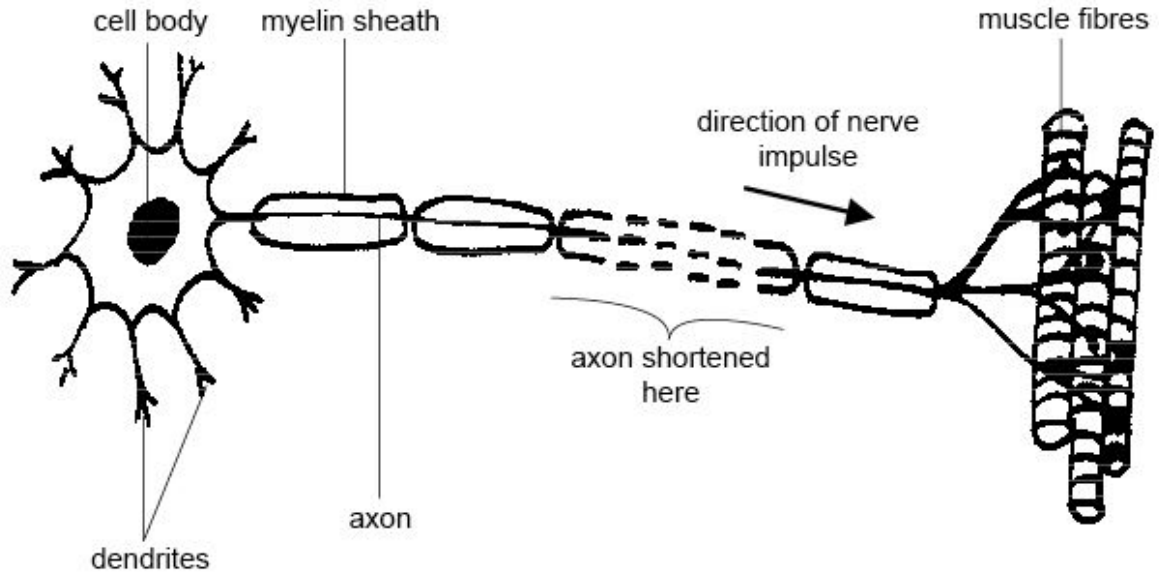

Figure 1: Motor Neuron

The cell body of neurons is located in the brain or spinal cord and the axon extends to the organ or muscle it supplies. A nerve is a bundle of axons. A sensory neuron transmits impulses for a sense receptor to the brain or spinal cord. A motor neuron transmits impulses from the brain or spinal cord to a muscle or gland. A relay neuron connects sensory and motor neurons, and is found in the brain or spinal cord.

The connection between adjacent neurons is called a synapse. The nerve cells do not touch but the electrical impulse in the neuron stimulates the production of neurotransmitters which are secreted into the gap between the nerve cells. When they come into contact with the membrane of the next nerve cell, they stimulate a new nerve impulse. Once the impulse is passed to the next nerve cell, the neurotransmitter is destroyed and the synapse is ready to receive the next impulse.

The Reflex:

A reflex is an automatic automatic response to a stimulus. For example, pinching the webbing between a dog's toes will cause the dog to jerk its paw away. The path taken by a nerve impulse in a reflex is a reflex arc. Most reflex arcs involve three neurons. Consider the previous example. The pinch stimulates pain receptors which initiate a nerve impulse in a sensory neuron. This impulse travels to the spinal cord where it passes to a relay neuron through a synapse. The relay neuron synapses with motor neurons that transmit the impulse to the muscles in the limb, causing them to contract and jerk the paw away.

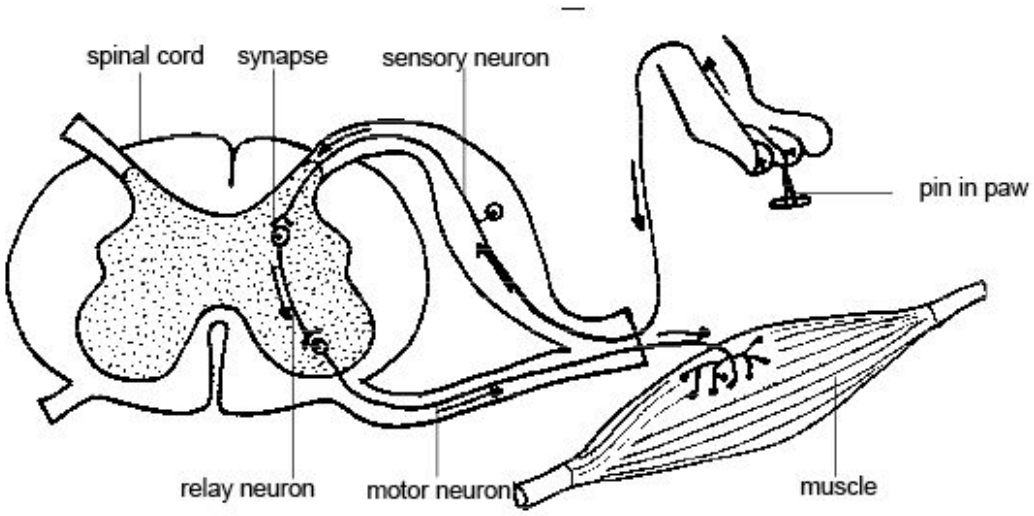

Figure 2: Reflex Arc

Conditioned reflexes occur when the stimulus and response are related, and animals can be trained to respond to different stimuli. For example, a dog will salivate when a bell is rung as was the case with Pavlov's dog.

Central Nervous System:

The central nervous system is made up of the brain, brain stem and spinal cord. It sends out nerve impulses and analyzes information from the sense organs, which tell the brain what a dog hears, sees, smells, feels and tastes.

The autonomic nervous system arises from the central nervous system and contains nerves which control involuntary movements of organs such as the intestines, heart, blood vessels, bladder, etc. Dogs have no voluntary control over the autonomic nervous system. It functions automatically.

When you look at the brain or spinal cord, some regions appear white, and are called white matter, while other regions appear grey and are called grey matter. White matter consists of masses of nerve axons and grey matter consists of nerve cells. In the brain, the grey matter is on the outside and in the spinal cord, it is on the inside.

The major part of the brain lies protected within the skull or cranium. Surrounding the brain tissue and spinal cord are protective membranes called the meninges, and a clear cerebrospinal fluid with protects and nourishes brain tissue. This fluid fills four cavities or ventricles within the brain.

The brain consists of three major regions:

1. The forebrain which includes the cerebral hemispheres, hypothalamus and pituitary gland
2. The hind brain or brain stem which contains the medulla oblongata and the pons
3. The cerebellum

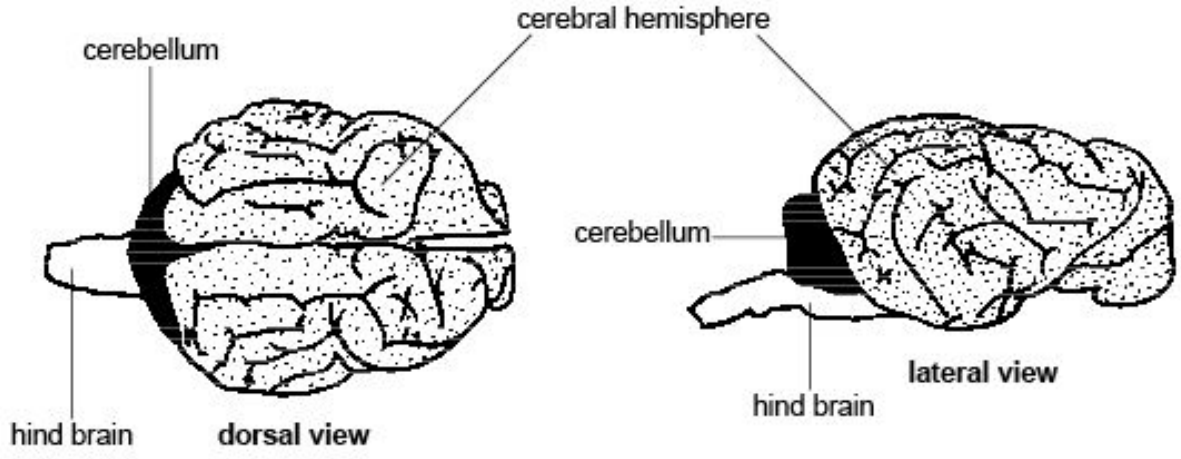

Figure 3: Dorsal and Lateral Views of the Brain

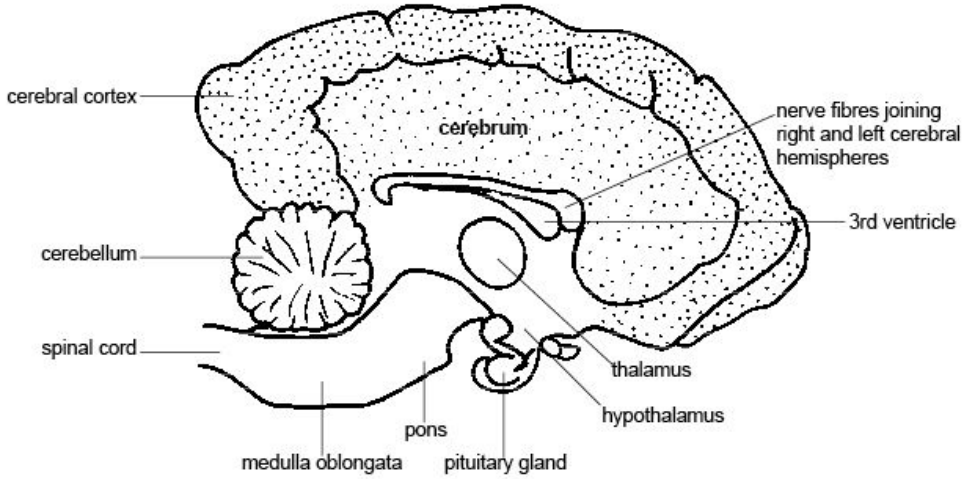

Figure 4: Longitudinal Section Through the Brain

In the forebrain, the cerebral hemispheres are the masses of brain tissue that sit on the top of the brain. The surface is folded into ridges and furrows called sulci. The two hemispheres are separated by a deep groove although they are connected internally by a thick bundle of nerve fibres. The outer layer of each hemisphere is called the cerebral cortex, and this is where the main functions of the cerebral hemispheres are carried out.

The main functions of the cerebral cortex are related to memory, learning, reasoning and intelligence. Nerves from the eyes, ears, nose and skin bring sensory impulses to the cortex where they are interpreted, and appropriate voluntary movements are then initiated here. Different regions of the cortex are responsible for certain sensory and motor functions, for example, vision, hearing, taste, smell, moving limbs or tail. If a dog sniffs a scent, sensory impulses from the organ of smell in the nose pass via the olfactory nerve to the olfactory centers in the cerebral hemispheres where the impulses are interpreted and co-ordinated.

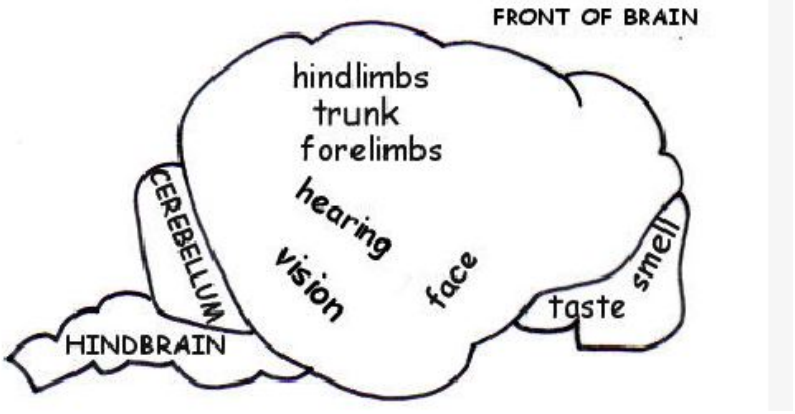

Figure 5: Functions of Regions in the Cerebral Cortex

The hypothalamus is situated at the base of the brain and is connected to the pituitary gland by a stalk. The pituitary gland is the hormone producing gland, and the hypothalamus is the bridge between the nervous and the endocrine system. It produces some of the hormones that are released from the pituitary gland and controls the release of others from it. It is also important for controlling the internal environment of the animal and maintaining homeostasis.

In the hindbrain or brain stem, the medulla oblongata is at the base of the brain, and is a continuation of the spinal cord. It carries all signals between the spinal cord and the brain, and contains centers that control vital body functions like breathing, heartbeat, and digestion. It also co-ordinates swallowing, vomiting, coughing, and sneezing.

The cerebellum is attached to the back of the brain and receives impulses from the vestibular organ in the inner ear and from stretch receptors in the muscles and tendons. It regulates muscle contraction during walking and running, and helps maintain the posture and balance of the animal.

Vertebrae consist of a body which encloses the vertebral foramen through which the spinal cord and meninges run, a spinous process, a transverse process, and articular process by which they join together. The landmarks of the vertebrae are as follows:

Vertebra	***Region***	***Common Name***
C7	Cervical	Neck
T13	Thoracic	Back
L7	Lumbar	Loins
S3	Sacral	Croup
Cd20-23	Caudal	Tail

The first two cervical vertebrae are called the atlas and the axis, and allow movement of the head. The nuchal ligament connects the spinous process of the axis to the spinous process of the first thoracic vertebra (T1). The last cervical vertebra (C7) articulates with the first pair of ribs. Thoracic vertebrae articulate with the ribs and the sacral vertebrae articulate with the pelvic girdle.

The spinal cord is a cable of nerve tissue that passes down the channel in the vertebrae from the hindbrain to the end of the tail. It becomes progressively smaller as paired spinal nerves pass out of the cord to parts of the body. Protective membranes or meninges cover the corn and these enclose spinal fluid.

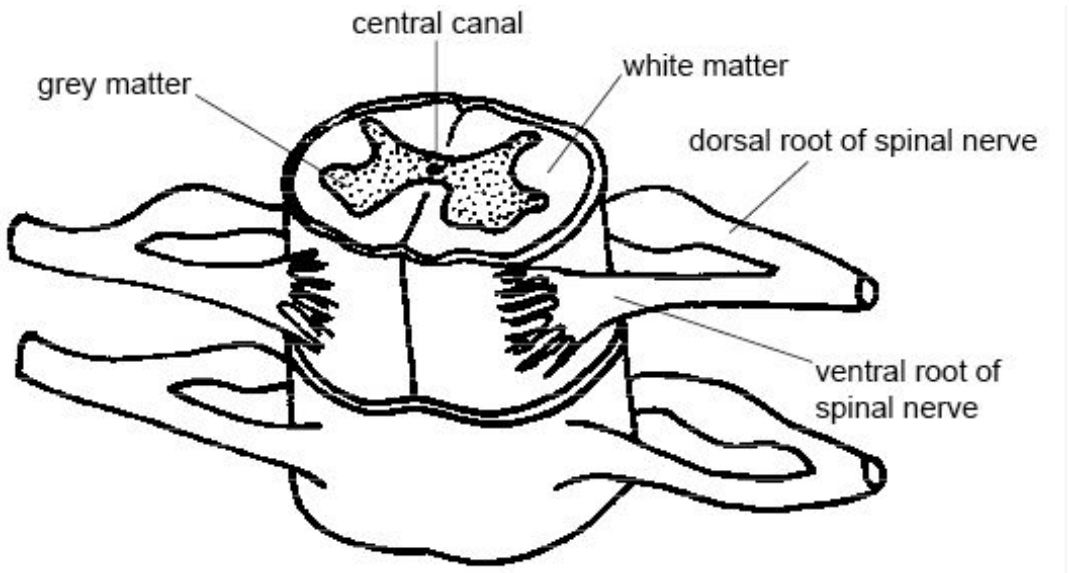

Figure 6: Spinal Cord

Peripheral Nervous System:

The peripheral nervous system includes cranial nerves that run from the brain to areas of the head and neck, and also the spinal nerves that enter and exit the spinal cord. These nerves carry messages from the central nervous system to other parts of the

body such as the legs and tail. Nerve impulses travel from the brain, down the spinal cord, out the peripheral nerves, to the tissues and back again.
There are twelve pairs of cranial nerves that originate from the brain. Each pair passes through a hole in the cranium. The most important of these are the olfactory, optic, acoustic and vagus nerves.

The olfactory nerves are responsible for smell and carry impulses from the olfactory organ of the nose to the brain.

The optic nerves are responsible for sight and carry impulses from the retina of the eye to the brain.

The acoustic nerves are responsible for hearing and carry impulses from the cochlear of the inner ear to the brain.

The vagus nerve controls the muscles that promote swallowing. It also controls the muscles of the heart, airways, lungs, stomach and intestines.

The spinal nerves connect the spinal cord to sense organs, muscles and glands in the body. Pairs of spinal nerves leave the spinal cord and emerge between each pair of adjacent vertebrae. The sciatic nerve is the largest spinal nerve in the body. It leaves the spinal cord as several nerves that join to form a flat band of nervous tissue. It passes down the thigh towards the hind leg where it branches off to various muscles in this limb.

Peripheral nerves that go from the brain or spinal cord are called motor nerves and affect muscles. For example, they control movements, posture and reflexes. Peripheral nerves that return to the brain or spinal cord are referred to as sensory nerves. These nerves carry information such as pain sensation from the body's structures, for example fascia, back to the central nervous system.

Specific Canine Nerves

The Radial Nerve:
The radial nerve is the largest nerve in the front leg, and is responsible for extending the elbow, wrist and toes which are all joints distal to the shoulder. It originates under the upper front leg from a group of nerves called the brachial plexus. The brachial plexus is formed by the ventral branches of spinal nerves C6, C7, C8, T1 and T2, which are the last three cervical and first two thoracic nerves. The radial nerve is formed by spinal nerves C7, C8, T1 and T2 which are the last two cervical and first two thoracic nerves.

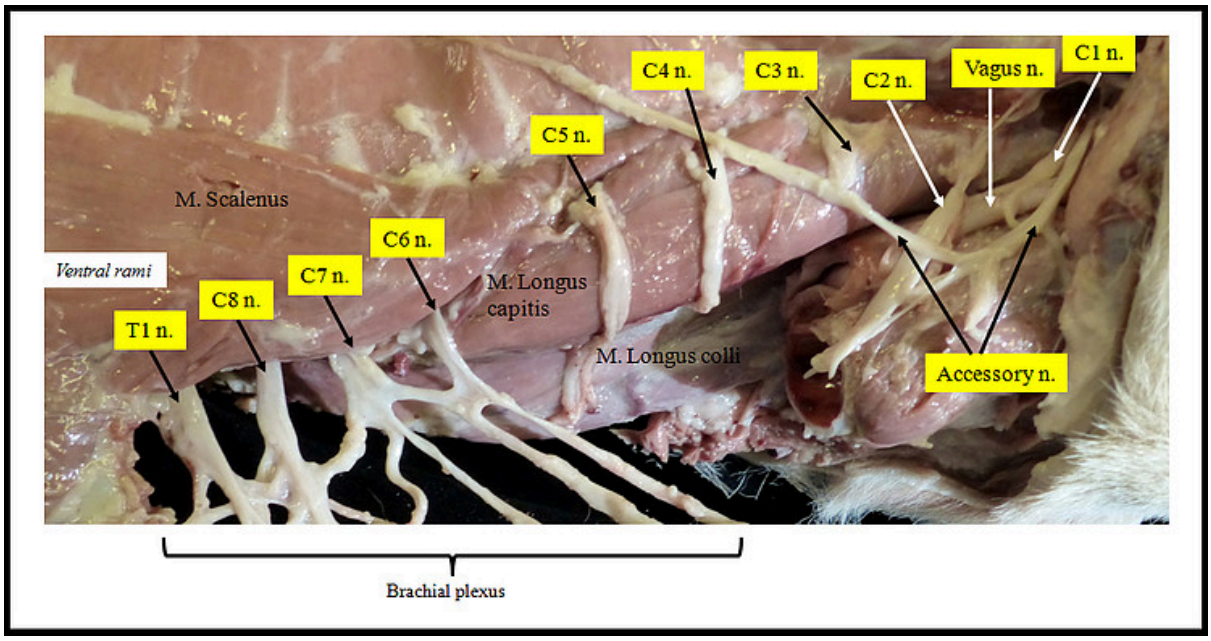

Figure 7: Brachial Plexus

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The radial nerve is the primary nerve of support for the limb and if injured, the dog's mobility and stability will be tremendously impacted. Dogs with radial nerve paralysis lose the ability to control their triceps and the muscles that extend down the front leg. Consequently, the limb cannot be placed in a fixed standing position and is unable to bear body weight. The leg will remain flexed or bent, and may dangle in front of the dog.

The course of the radial nerve is as follows:

- Branches enter the triceps muscle distal to the shoulder
- Continuation runs deep to the biceps muscle and medial head of the triceps muscle
- It then spirals around the distocaudal aspect of the humerus and is found on the lateral aspect of the brachium (upper segment of the arm or forelimb extending from the shoulder to the elbow) between the brachialis muscle (muscle in the upper forelimb that flexes the elbow joint) and the lateral head of the triceps brachii muscle
- Here it splits into a superficial branch which is sensory and a deep branch which is motor (see Figures 8 and 9)

Since the radial nerve originates from the brachial plexus, Moves 11 and 13 would address this nerve. I also think that Move 9 would address it indirectly, as well as Moves 2 and 8.

Figure 8: Superficial Radial Nerve

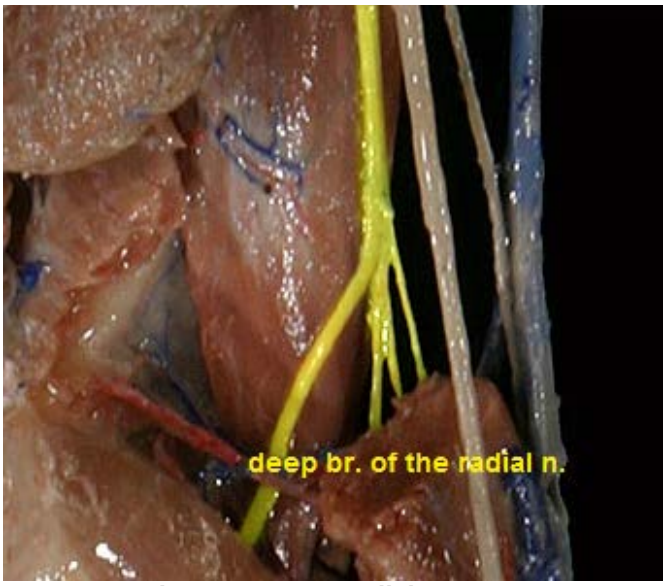

Figure 9: Deep Radial Nerve

The Median Nerve:

The median nerve, in conjunction with the ulnar nerve, innervates most of the muscles that flex the wrist and toes which is the caudal group of antebrachial muscles. It also originates under the upper front leg from the group of nerves called the brachial plexus. It is formed by spinal nerves C8, T1 and T2 which are the last cervical nerve and the first two thoracic nerves.

In paralysis of the median nerve, the gait is normal but cutaneous sensation is absent on the palmar surface of the medial three digits. Muscles responsible for flexing the wrist and digits may also atrophy.

The course of the median nerve is as follows:

- Arises by common origin with the ulnar nerve and runs distad (towards distal) on the deep side of the medial head of the triceps muscle
- After splitting from the ulnar nerve, it continues distad following the course of the brachial artery
- On the medial aspect of the elbow, it runs deep to the pronator teres muscle where it gives off muscular branches
- The distal continuation parallels the median artery and passes through the carpal canal to the paw

Since the median nerve originates from the brachial plexus, Moves 11 and 13 would address this nerve. I also think that Move 9 would address it indirectly, as well as Moves 2 and 8.

Figure 10: Cranial, Medial and Caudal Aspects of Median Nerve

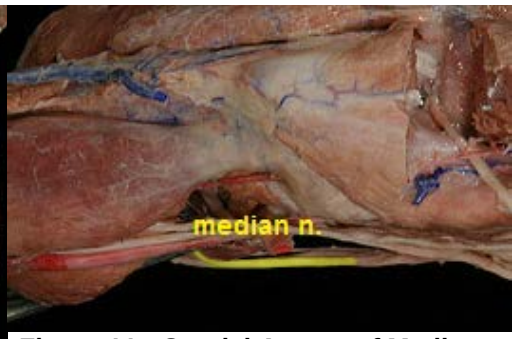

Figure 11: Cranial Aspect of Median Nerve

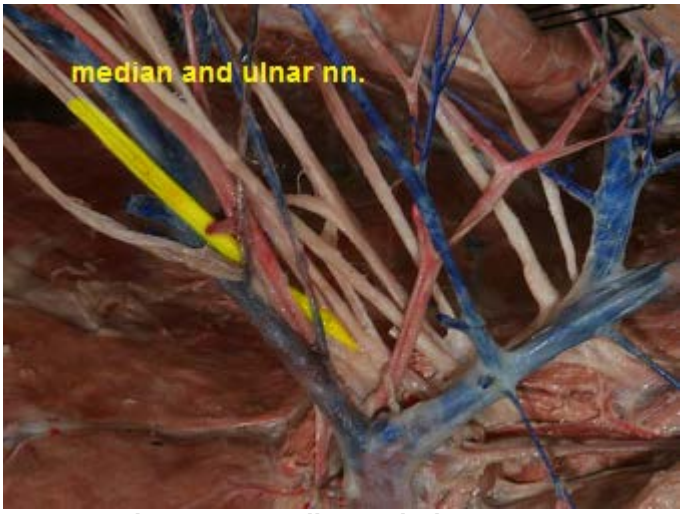

Figure 12: Median and Ulnar Nerve

The median and ulnar nerves are frequently considered as a unit, since they supply all of the flexor muscles of the carpus (wrist) and digits, but the areas of cutaneous (skin) sensation differ.

The Ulnar Nerve:

The ulnar nerve, in conjunction with the median nerve, innervates most of the muscles that flex the wrist and toes which is the caudal group of antebrachial muscles. It also originates under the upper front leg from the group of nerves called the brachial plexus. It is formed by spinal nerves C8, T1 and T2 which are the last cervical nerve and the first two thoracic nerves.

In paralysis of the ulnar, atrophy of the flexors of the carpus and digits may be apparent. These flexors are dually innervated except near the ulnar and median nerves. The carpus sags to an overextended angle on weight bearing in ulnar paralysis and cutaneous sensation is absent on the caudal and caudolateral sides of the antebrachium (forearm between elbow and wrist), carpus, metacarpus (bones between wrist and digits), palmar surface of digits 4 and 5, and the dorsal and lateral surfaces of digit 5.

The course of the ulnar nerve is as follows:

- Diverges from the median nerve in the distal brachium, and passes distocaudad across the elbow, running parallel to the collateral ulnar artery
- Runs under the ulnar head of the flexor carpi ulnaris muscle (this muscle flexes the carpus and is innervated by the ulnar nerve)
- Gives rise to muscular and sensory branches in the caudal region of the antebrachium

Since the median nerve originates from the brachial plexus, Moves 11 and 13 would address this nerve. I also think that Move 9 would address it indirectly, as well as Moves 2 and 8.

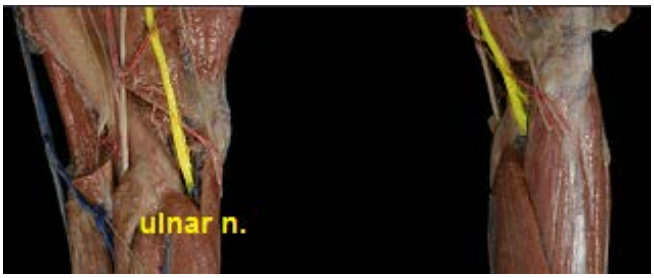

Figure 13: Medial and Caudal Aspect of Ulnar Nerve

Figure 14: Cranial Aspect of Ulnar Nerve

The Femoral Nerve:

The femoral nerve innervates the cranial muscles of the thigh and originates from a group of nerves called the lumbosacral plexus. The lumbosacral plexus is formed by the fourth through seventh lumbar nerves and all sacral nerves. The femoral nerve is formed by spinal nerves L4, L5, and L6.

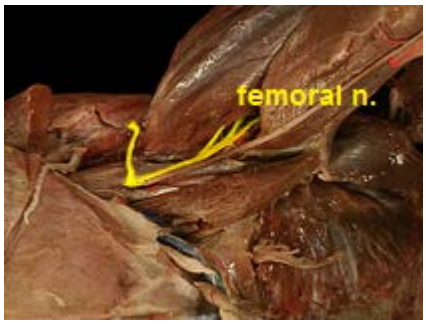

Figure 15: Femoral Nerve

Figure 16: Femoral Nerve in Iliopsoas Muscle

It emerges from the body of the iliopsoas muscle, and immediately divides into multiple motor branches in the region of the femoral triangle. It innervates hip flexor muscles and muscles responsible for the extension of the stifle. There are no cutaneous branches arising directly from the femoral nerve.

Disease that affects any of the vertebrae from the caudal end of L4 through the sacrum may cause signs recognizable as motor or sensory abnormality in the nerves of the pelvic limbs and perineal region, autonomic functional abnormalities of the pelvic viscera, or both.

Moves 1, 3, 4, 4a, 5, 6, and 7 would all address this nerve.

The Sciatic Nerve:

The sciatic nerve, the largest nerve in the body, arises from the lumbosacral trunk which is formed by spinal nerves L6, L7, S1 and S2. The trunk becomes the sciatic nerve after it is joined by the S2 ventral branch, which occurs after the trunk gives off the cranial and caudal gluteal nerves. It leaves the pelvis at the greater sciatic notch and curves in a ventral caudal direction around the hip joint. It runs distocaudally over the femur, between the biceps femoris medially and the adductor, semimembranosus and semitendinosus muscles medially.

After sending branches to the hamstring muscles, the sciatic innervates muscles of the crus (lower leg) with two branches: the tibial nerve to caudal muscles and the common fibular (peroneal) nerve to cranial muscles. It divides where cutaneous fibers run.

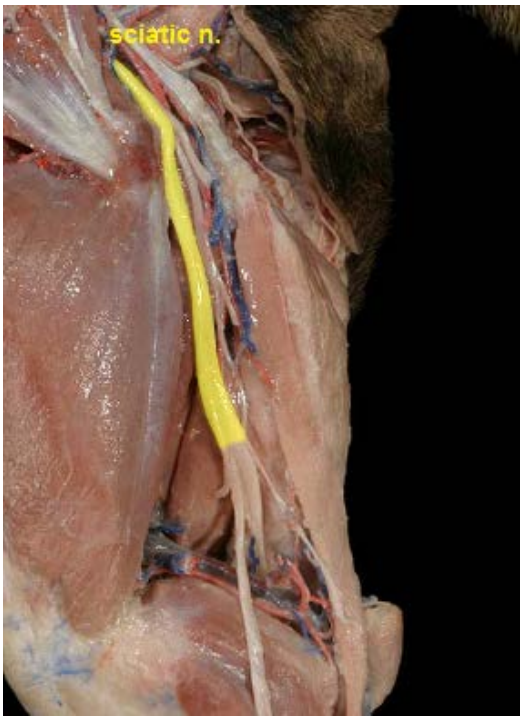

Figure 17: Sciatic Nerve

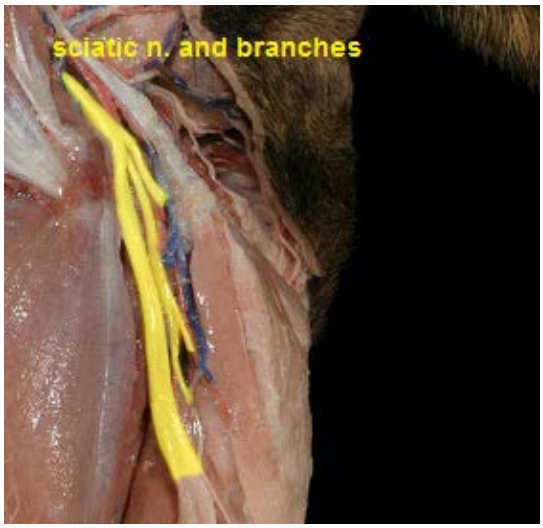

Figure 18: Sciatic Nerve and Branches

The sciatic nerve or its branches may be injured by pelvic fractures, during or after retrograde placement of intramedullary pins in the femur, or by injections of irritating substances in or near the nerve. Damage to the proximal aspect of the sciatic nerve causes monoparesis, or paralysis of a single limb, with inability to flex the stifle. The hock and digits cannot flex or extend, and weight is supported on the dorsal surface of

the foot with the hock excessively flexed. There may be loss of sensation below the stifle except for the medial aspect, which is innervated by a branch of the femoral nerve. Moves 1, 3, 4, 4a, 5, 6, and 7 would all address this nerve.

The Tibial Nerve:

The tibial nerve's origin is the spinal nerves L7 and S1, which are the last lumbar nerve and the first sacrum nerve. It arises from the sciatic nerve in the thigh region, passes between two heads of the gastrocnemius muscle, and runs caudal to the stifle joint.

Its motor innervation is the gastrocnemius and popliteus muscles, and superficial and deep digital flexor muscles. Its sensory innervation is the plantar aspect of the tarsus, metatarsus, and digits.

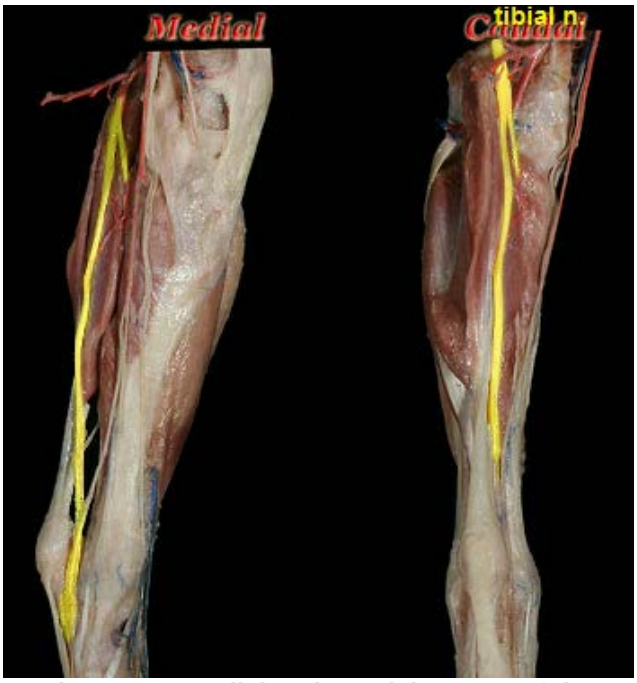

Figure 19: Medial and Caudal Aspect of the Tibial Nerve

Figure 20: Medial and Caudal Aspect of The Tibial Nerve with a View of the Digits

Injury to the tibial nerve results in inability to extend the hock or flex the digits as well as reduced sensation over the plantar surface of the foot.

Moves 1, 3, 4, 4a, 5, 6, and 7 would all address this nerve.

The Vagus Nerve:

The vagus nerve is part of the group of cranial nerves responsible for innervation of structures derived from the pharyngeal or aortic arches. These arches are a series of six paired embryological vascular structures which give rise to the great arteries of the neck and head. They are ventral to the dorsal aorta and arise from the aortic sac. The aortic arches are formed sequentially within the pharyngeal arches and initially appear

symmetrical on both sides of the embryo, but then undergo a significant remodelling to form the final asymmetrical structure of the great arteries.

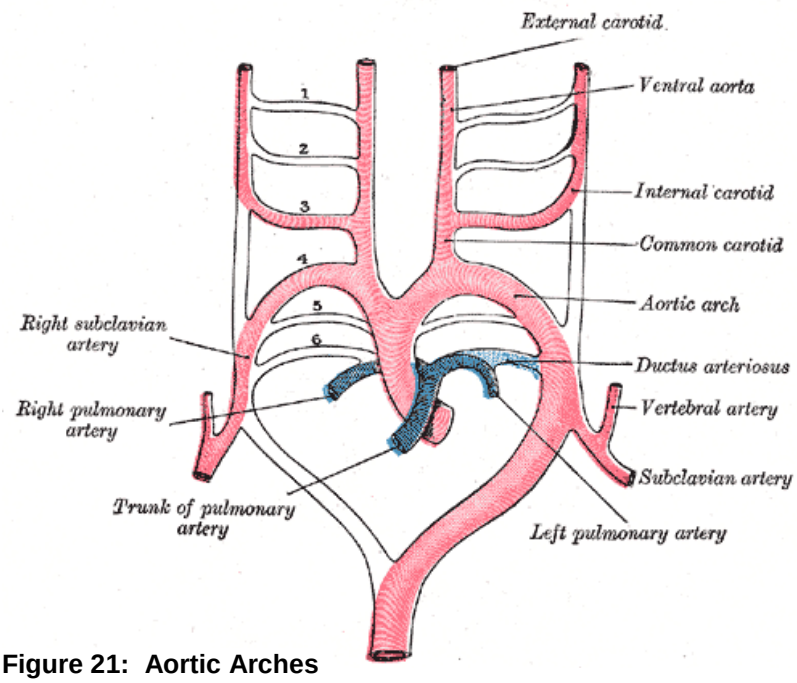

Figure 21: Aortic Arches

The vagus nerve is also part of a group, together with the glossopharyngeal and accessory nerves, which passes through the jugular foramen, called the vagus group.

The vagus nerve innervates structures related to the fourth aortic arch and has cell bodies that are referred to as nucleus ambiguus.

The left fourth aortic arch becomes the adult arch of the aorta. The right fourth aortic arch becomes the proximal part of the right subclavian artery as the distal connection between the arch and the dorsal aorta normally degenerates. Persistence of a connection between the fourth aortic arch and the descending aorta results in compression of the esophagus, accompanied difficulty in swallowing, and an enlarged esophagus cranial to the compression.

The vagus nerve is first identifiable close to the ventral skull where a vague dilation represents the distal ganglion of the vagus nerve. It is a sensory ganglion or cluster of nerve cells. The vagus is readily identifiable as a component of the vagosympathetic trunk within the carotid sheath with the common carotid artery.

The somatic nervous system is the portion of the vertebrate nervous system which regulates voluntary movements of the body. The vagus nerve regulates voluntary movements of the laryngeal, pharyngeal and esophageal muscles.

The parasympathetic nervous system is responsible for stimulation of activities that only occur when the body is at rest. The vagus nerve stimulates all thoracic viscera, and most abdominal viscera, and receives the sense of taste from the epiglottis.

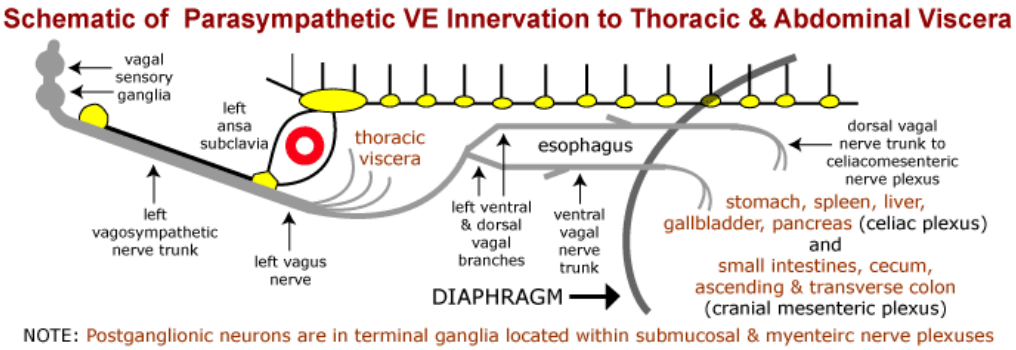

Figure 22: Path of the Vagus Nerve and Its Branches

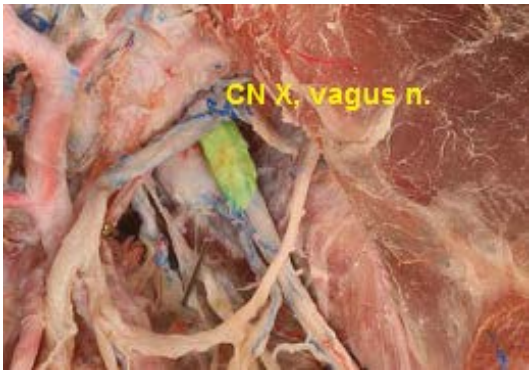

Figure 23: Distal Ganglion of the Vagus Nerve

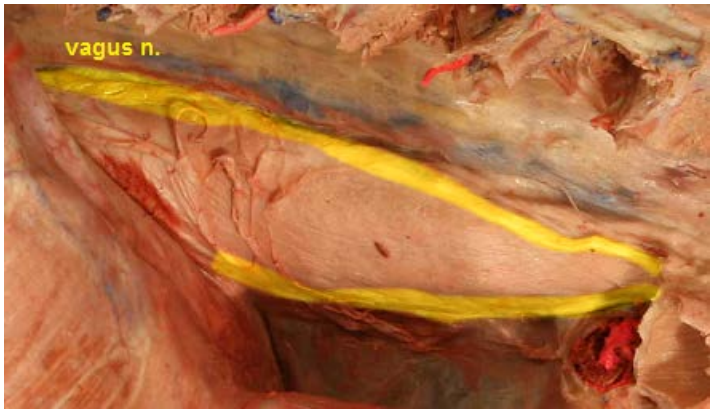

Figure 24: Right Thorax Dissection - Vagus Nerve

One disorder of the vagus nerve is non heart-related fainting. This is caused when the vagus nerve becomes overactive. It is responsible for slowing heart rate, and anything that puts pressure on the vagus nerve and triggers it can cause dramatic slowing of the heart rate. Straining to pass feces, or even coughing, can increase pressure in the chest and stimulate the vagus nerve, resulting in a faint.

Massage can help the dog relax by releasing acetylcholine. This slows the dog's heart rate and breathing, and lowers blood pressure and cortisol levels, since moderate pressure massage works primarily on a dog's parasympathetic nervous system, including the vagal nerve pathways. This explains why dogs like to have their ears rubbed since the vagus nerve serves a large part of the midportion of the ear.

Since the vagus nerve is the longest nerve in the body, wandering from the brain stem to the lowest viscera of the dog's abdomen, Moves #10, 12, and 13 would address this nerve.