Bowen Questions Part 1

1. What is a neuron?

What Exactly Is a Neuron?

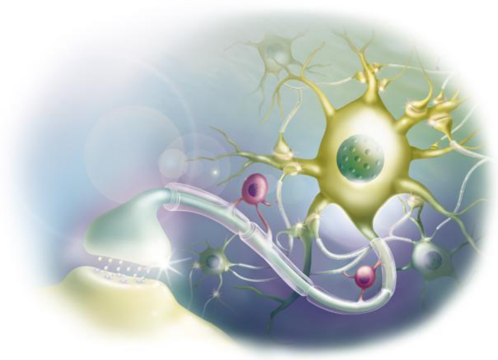


Photo Credit: BSIP/UIG / Universal Images Group / Getty Images

Neurons are the basic building blocks of the nervous system. These specialized cells are the information-processing units of the brain responsible for receiving and transmitting information. Each part of the neuron plays a role in the communication of information throughout the body. Follow the links below to learn more about the functions of each part of a neuron.

These highly specialized nerve cells are responsible for communicating information in both chemical and electrical forms.
There are also several different types of neurons responsible for different tasks in the human body.

Sensory neurons carry information from the sensory receptor cells throughout the body to the brain. Motor neurons transmit information from the brain to the muscles of the body. Interneurons are responsible for communicating information between different neurons in the body.

Neurons vs. Other Cells

Similarities with other cells:
•Neurons and other body cells both contain a nucleus that holds genetic information.
•Neurons and other body cells are surrounded by a membrane that protects the cell.
•The cell bodies of both cell types contain organelles that support the life of the cell, including mitochondria, Golgi bodies, and cytoplasm.

Differences that make neurons unique:

•Unlike other body cells, neurons stop reproducing shortly after birth. Because of this, some parts of the brain have more neurons at birth than later in life because neurons die but are not replaced. While neurons do not reproduce, research has shown that new connections between neurons form throughout life.

The Key to Change Your Life is to "Jump" Into Your Subconscious...

•Neurons have a membrane that is designed to sends information to other cells. The axon and dendrites are specialized structures designed to transmit and receive information. The connections between cells are known as synapses. Neurons release chemicals known as neurotransmitters into these synapses to communicate with other neurons.

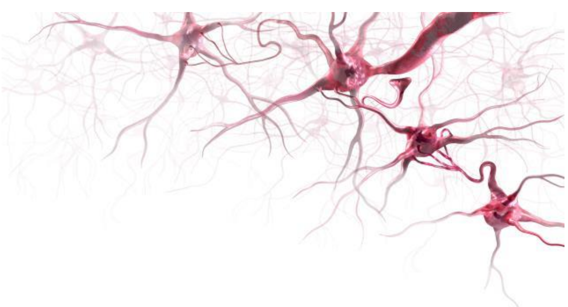
http://psychology.about.com/od/biopsychology/f/neuron01.htm

2. How is it formed?

The Structure of a Neuron

There are three basic parts of a neuron: the dendrites, the cell body and the axon. However, all neurons vary somewhat in size, shape, and characteristics depending on the function and role of the neuron. Some neurons have few dendrite branches, while others are highly branched in order to receive a great deal of information. Some neurons have short axons, while others can be quite long. The longest axon in the human body extends from the bottom of the spine to the big toe and averages a length of approximately three feet!
http://psychology.about.com/od/biopsychology/f/neuron01.htm

3. What does a Dendrite do?



Dendrites serve as the input region of the neuron and receive information from other cells. Photo Credit: Henning Dalhoff / Science Photo Library / Getty Images

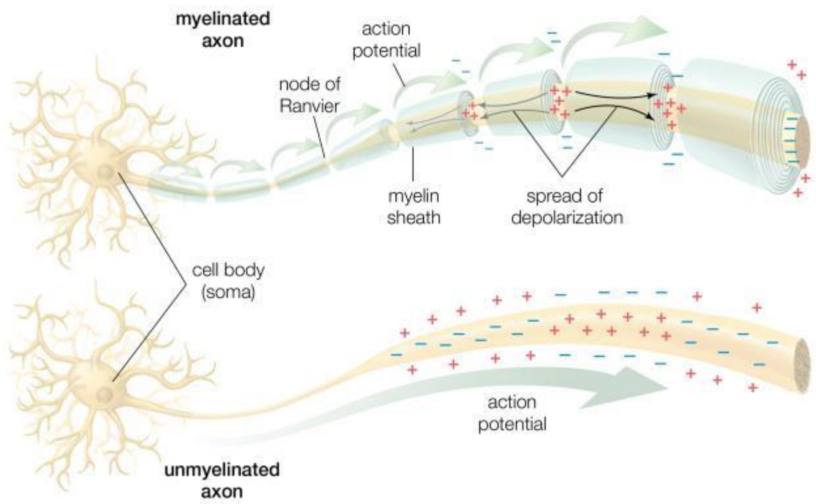
Dendrites are treelike extensions at the beginning of a neuron that help increase the surface area of the cell body. These tiny protrusions receive information from other neurons and transmit electrical stimulation to the soma. Dendrites are also covered with synapses.

Dendrite Characteristics

- Most neurons have many dendrites
- However, some neurons may have only one dendrite
- Short and highly branched
- Transmits information to the cell body

http://psychology.about.com/od/biopsychology/ss/neuronanat.htm#step2

4. What does an Axon do?



The axon transmits information away from the cell body. Photo Credit: Encyclopaedia Britannica/UIG Universal Images Group/Getty Images

The axon is the elongated fiber that extends from the cell body to the terminal endings and transmits the neural signal. The larger the axon, the faster it transmits information. Some axons are covered with a fatty substance called myelin that acts as an insulator. These myelinated axons transmit information much faster than other neurons.

Axon Characteristics

- Most neurons have only one axon
- Transmit information away from the cell body

- May or may not have a myelin covering

http://psychology.about.com/od/biopsychology/ss/neuronanat.htm#step5

6. What is the function of a Sensory Neuron?

Sensory neurons carry information from the sensory receptor cells throughout the body to the brain. Motor neurons transmit information from the brain to the muscles of the body. Interneurons are responsible for communicating information between different neurons in the body.

http://psychology.about.com/od/biopsychology/f/neuron01.htm

7. What is the function of a Motor Neuron?

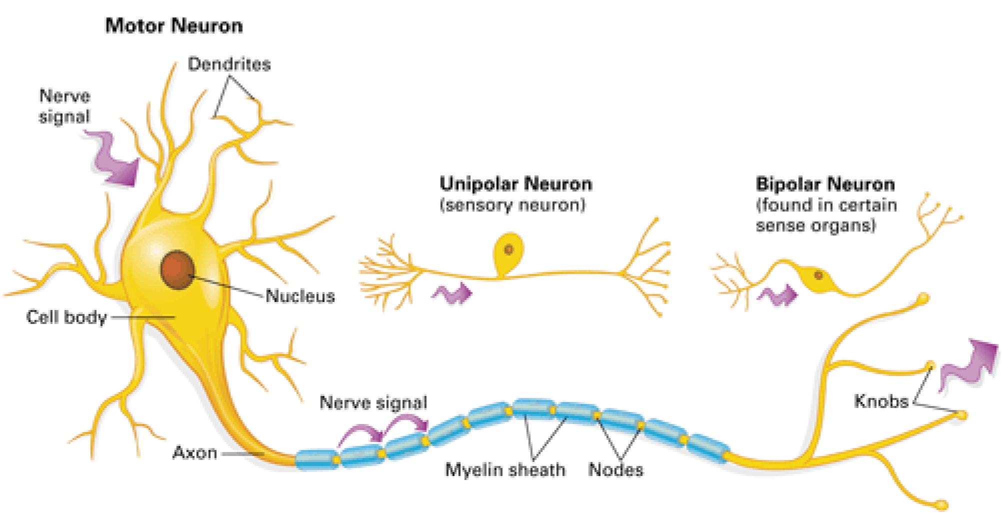
The function of a motor neuron is to carry an electrical signal to a muscle, triggering it to either contract or relax. In vertebrate animals, including humans, movement of the articulated internal skeletal structure is enabled by coordinating the contractions of the many muscles attached to it. Only the brain is capable of this complex coordination, and electrical signaling is arguably the only means fast enough to deliver its instructions to far flung muscles. The medium of delivery are electrically excitable cells called neurons.

A motor neuron, sometimes combined into the singular term motoneuron, is a nerve cell. Its basic structure includes a receptor on one end and a transmitter on the other, connected by an elongated body called the axon, some of which can be 39 inches (1m) long in humans. Chains of nerve cells, end to end, are bundled into nerve fibers which reach from the brain to the finger muscles and further.

http://www.wisegeek.com/what-is-the-function-of-a-motor-neuron.htm#

Motor neuron

In vertebrates, motor neurons (also called motoneurons) are efferent neurons that originate in the spinal cord and synapse with muscle fibers to facilitate muscle contraction and with muscle spindles to modify proprioceptive sensitivity.
http://www.sciencedaily.com/terms/motor_neuron.htm

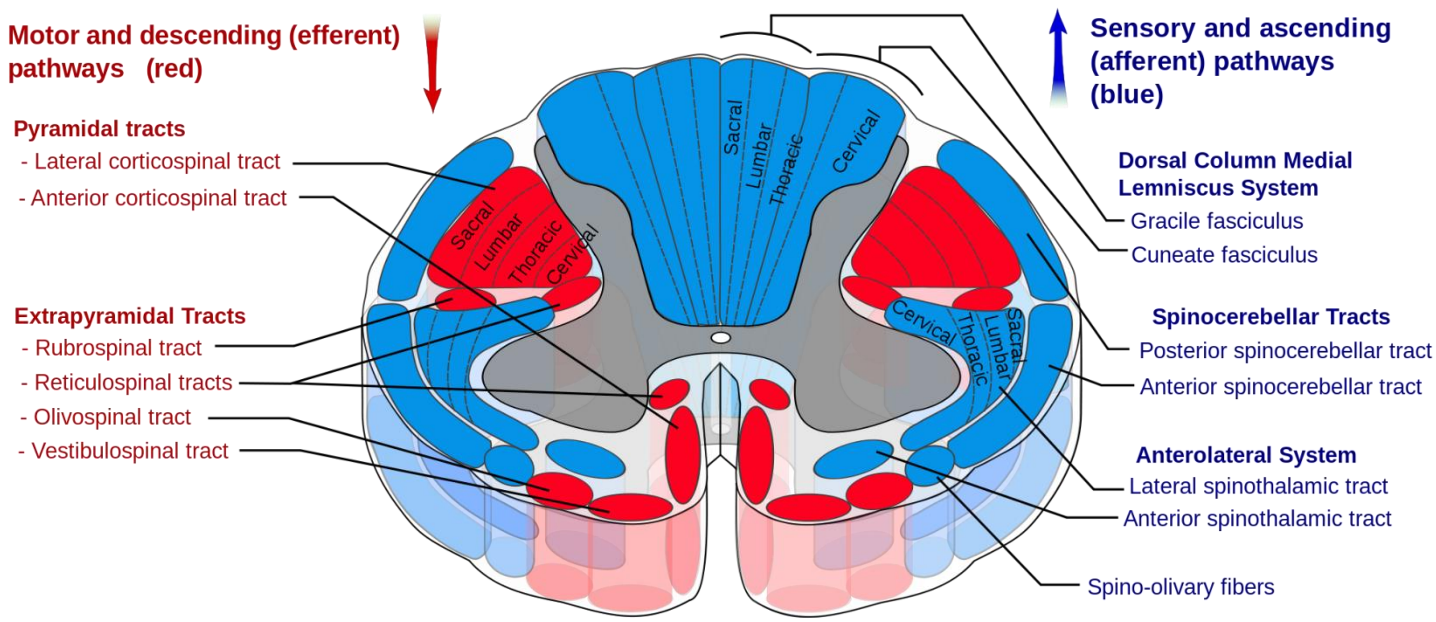


http://www.visembryo.com/story3004.html

8. Inside the spinal cord, axons or motor neurons form bundles known as tracts. What is the spinal tracts function?

Spinal tract,
any one of the ascending (sensory) and descending (motor) pathways for sensory or motor nerve impulses that is found in the white matter of the spinal cord. Twenty-one different tracts lie within the dorsal, ventral, and lateral funiculi of the white substance. Ascending tracts conduct impulses up the spinal cord to the brain; descending tracts conduct impulses down the cord from the brain. The four major ascending tracts are the lateral spinothalamic, the ventral spinothalamic, the fasciculi gracilis and cuneatus, and the spinocerebellar. The four major descending tracts are the lateral corticospinal, the ventral corticospinal, the lateral reticulospinal, and the medial reticulospinal. Touch, pressure, proprioception, temperature, and pain are sensory stimuli transmitted via the spinal tracts. Reflex and voluntary motor activity is regulated by motor nerve stimulation from the brain and brainstem to the motor neurons of the spinal cord.
http://medical-dictionary.thefreedictionary.com/spinal+tract

The spinothalamic tract (also known as anterolateral system or the ventrolateral system) is a sensory pathway from the skin to the thalamus. From the ventral poster lateral nucleus in the thalamus, sensory information is relayed upward to the somatosensory cortex of the post central gyrus.



https://en.wikipedia.org/wiki/Spinothalamic_tract

9. Neurons work to send signals to the brain. Name the parts and the functions of the Canine Brain.

Telencephalon

- The front part of the brain is called the telencephalon. Information from the five senses is interpreted there, and it is also where thought occurs. Dogs have large telencephalons which makes their ears, nose and eyes exceptionally sensitive. It also is responsible for dogs' undeniable personalities, and their advanced social behaviors.

Diencephalon

- Behind the telencephalon lies the diencephalon. Most basic functions are controlled in this portion of the brain. Chewing, breathing, equilibrium and the collection of information from the senses all occur here. This part of the brain is highly advanced in dogs, contributing to their fast reflexes, agility and the acuteness of their hearing.

Metencephalon

- This part of the brain is behind the diencephalon. It is responsible for finer muscle skills and the regulation of blood flow and pulse rate, and is also the brain's reward center. For dogs, this part of the brain contributes to their remarkable endurance and stamina and is the part of the brain responsible for their love of playing fetch and other games.

Medulla Oblongata

- At the base of a dog's brain, where it connects to the spinal cord, is a structure known as the medulla oblongata. Here the basic functions that occur without thinking are regulated. Digestion, heartbeat, respiration, swallowing and sneezing are all controlled in this area of the brain. The medulla oblongata is the first part of the brain that develops in puppies before they are born.

Corpus Callosum

- In the middle of a dog's brain is the corpus callosum. This is a wall of nerve cells which facilitates communication between the left and right side of the telencephalon and diencephalon. Depending on the breed of dog, the corpus callosum's size and the speed at which it allows the halves of the brain to interact can vary significantly.

Read more: http://www.ehow.com/about_6765749_anatomy-dog-brain.html

Ever wondered how your dog’s brain works? A brief guide…

Your dog’s brain is a sophisticated organ – it controls his thinking, learning, and actions. It’s also responsible for interpreting and integrating information from all over the body, much like our human brains. And, in February 2014, research led by Dr Attila Andics revealed more similarities.

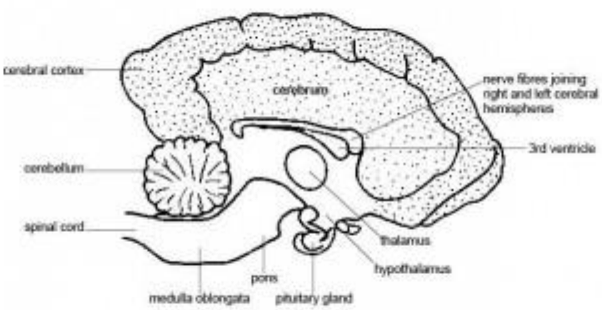
The study made by the University of Budapest revealed that a dog’s brain reacts to voices in the same way as a human brain. Eleven dogs and owners where each placed in an MRI scanner and played over 200 different sounds – from car sounds and whistles to human sounds and dog noises. The researchers found that a similar region – the temporal pole, which is the most anterior part of the temporal lobe, was activated when both the animals and people heard human voices. *“We do know there are voice areas in humans, areas that respond more strongly to human sounds that any other types of sounds,”* Dr Andics explained. *“The location (of the activity) in the dog brain is very similar to where we found it in the human brain. The fact that we found these areas exist at all in the dog brain at all is a surprise – it is the first time we have seen this in a non-primate.”* The fact that emotionally charged sounds, such as crying or laughter prompted similar responses to humans as it did with the dogs tested might also perhaps explain why dogs are attuned to human emotions.

But what else can we learn by studying our pet’s brain? Here’s a brief guide….

The size and weight of the brain varies greatly from species; the weight of the brain in an average dog is less than half of one per cent of its body weight – but it receives over twenty per cent of the blood pumped out of the heart. So, this shows how the brain is at the core of your dog’s activity, busy digesting data and determining the best course of action, which affects your pooch’s overall behaviour.

The brain is a mass of nerve tissue which is divided up into three main areas; the cerebrum, the cerebellum and the brain stem. Each part performs particular functions with information being fed into these key areas, so collectively they give instructions on the appropriate action.

The cerebrum or cerebral cortex forms the bulk of the brain. This is responsible for receiving and analyzing sensory information such as vision, hearing, touch, taste and pain. The larger the cerebral cortex in an animal, the more options of responses it has, enabling it to carry out complex behaviour patterns. For example; reptiles’ cerebral cortex is far less developed compared to your dog’s brain. This means, Fido can perform many tasks and has complex behaviour patterns compared to the reptile.



The cerebral cortex is divided up into two areas; the left and right cerebral hemispheres. The narrow slit separating these hemispheres is called the cerebral longitudinal fissure. Within these two areas are four lobes; the frontal, temporal, parietal and occipital lobe. The frontal and temporal lobes contribute to the alertness, intelligence (planning and execution of movements), memory and temperament of the dog. Within this area is the thalamus. This is responsible for relaying sensory information such as hearing, sight, touch and pain. The thalamus also enables your dog to selectively concentrate and focus on one thing at a time. The sensory and emotional information relayed to the thalamus is then sent to the parietal and occipital lobes of the dog's brain for decoding. Once this information has been digested and processed according to previous experiences or memories, the data is then sent to the frontal lobe and translated into plans and actions. The thalamus also contributes to the monitoring and regulation of motor activity initiated in the cerebral cortex. This information is then sent from the cerebral cortex to the cerebellum to aid the co-coordinating centre of the brain which is responsible for muscle activity.

Just below the thalamus is the hypothalamus. This area controls the release of the pituitary hormones (from the pituitary gland) and is responsible for regulating your pet's drinking and eating behaviour, as well as his body temperature, reproductive and autonomic nervous system; this system contains nerves which control involuntary movements of organs such as the intestines, heart, blood vessels and blood (dogs do not have voluntary control over the autonomic nervous system). Interestingly, emotions such as rage and aggression originate in the hypothalamus – although these are normally inhibited by the hippocampus and the frontal lobe of the cerebral cortex – if a dog contracts the rabies virus, this invades the hippocampus and removes this inhibition. This means the powerful aggressive urges of the hypothalamus are allowed to prevail. As you can see, your dog's brain is a complex machine, and within the cerebral cortex is the limbic system – this regulates the dog's emotions from fear, rage, and aggression to anxiety, joy and euphoria. It has an essential role in the learning process. The rabies virus will attack the limbic system and this demonstrates how any disturbances in this area can cause emotional and or behavioural problems.

Within the limbic system is the amygdala, this is responsible for survival strategies and defense responses. In times of extreme danger or a life and death situation a dog has to act quickly. So, in this instance the information of this situation is sent directly from the thalamus to the amygdala activating your dog's defence reactions at speed, rather than it being decoded first by the cerebral cortex which takes longer to process.

Little brain…

The second area of your dog's brain is the cerebellum (meaning 'little brain' in Latin). This is located at the back of the brain and is attached to the brain stem and cerebral cortex. The cerebellum is the part of the brain that regulates or is mostly responsible for the control and co-ordination of voluntary movement (muscles) and posture of your dog. The cerebellum is interconnected via thalamic relays with the sensory-motor area of the cerebral cortex. So, the cerebellum will receive information from the cerebral cortex about intended muscle activity and it will process and compare this information from receptors in your dog's muscles and tendons. Once the cerebellum has feedback the data, this ensures precision in movement. Any damage or cerebellar lesioning to this area will typically cause head or body tremors, poor balance, signs of clumsiness, exaggerated and awkward movements. The cerebellum, which is responsible for co-ordinated movement and the rest of the nervous system, is not fully developed at birth. While the brain, spinal cord and associated nerves are all present, the nerves lack the ability to efficiently transmit electrical impulses. Most people who have seen a new born puppy will notice how they are sluggish in movement and its pain sensation is very slow.

Brain stem

The third area of the brain is the brain stem. This is located at the base of the brain and is connected to the spinal cord and cerebellum. There are two main parts of the brain stem; the pons and the medulla oblongata. All the nerve fibres leaving the brain going to your dog's muscles, will pass through the brain stem. The medulla oblongata is situated at the base of the brain and connects to the spinal cord. It's responsible for regulating a number of functions from your dog's heart beat and his breathing to salivation, coughing, sneezing and his gastrointestinal functions. The medulla oblongata, together with the pons, is an important relay site for hearing and balance information, taste sensations and motor reactions. The pons provides a pathway for the nerves fibres to relay sensory information between the cerebellum and cerebral cortex. The pons also includes the micturition centre (urination). Studies in 1964 by Japanese scientists Kuru and Yamamoto, demonstrated how electrical stimulation to the pons resulted in an increase in urethral sphincter activity and the relaxation of the bladder. So, it's safe to assume that damage to the pons will contribute to urinary incontinence.

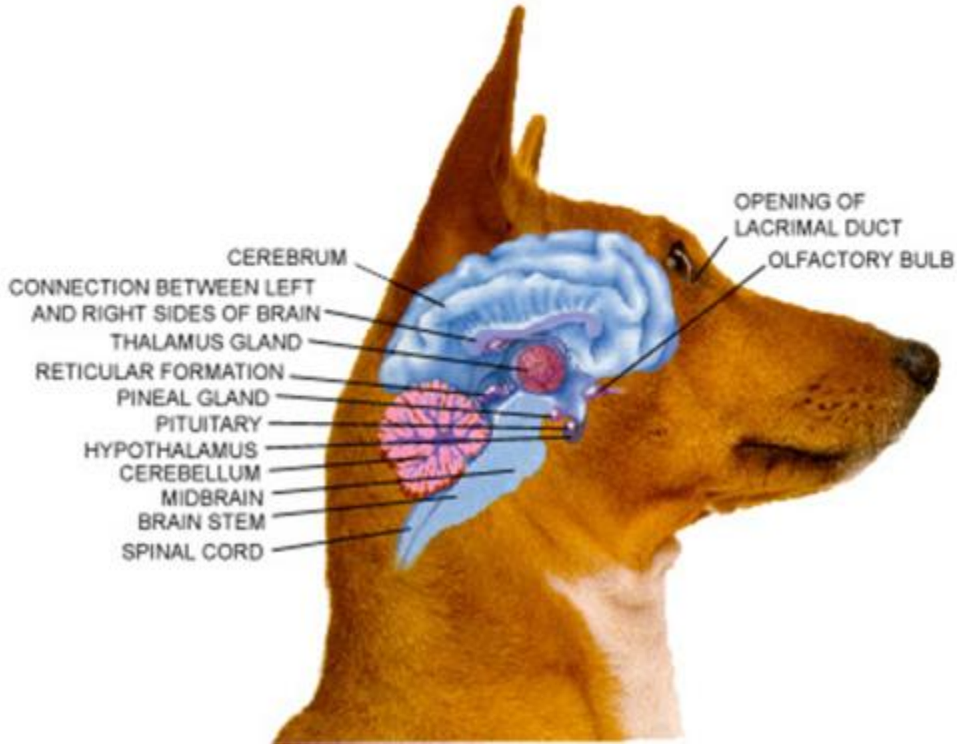
How does the brain receive and transmit information?

The central nervous system is comprised of the brain and spinal cord, but connected to these are a network of peripheral nerves (the peripheralnervous system) which penetrate and supply the tissues of the body and transmit pieces of information – such as pain sensation – to and from the body back to the nervous system. In turn, the brain reacts with a course of action. The brain cells that transmit information within the central nervous system are called neurones. Structurally a neuron is unlike any other cell in the body, made up of three parts; the cell body, an axon and dendrites.

The cell body is the large central portion of the cell containing the nucleus and is between the axon and dendrites. The axon is a slender tube that carries nerve impulses away from the neuron to the terminal buttons. Dendrites are short and tree-like; they receive messages from the other neurons. Between the axon terminal button of one cell (presynaptic cell) and the dendrites of the second or receiving cell (postsynaptic cell) is a junction called the synapse. The axon and dendrite in the two cells face each other and the synapse is the very small gap in between. When the information (referred to as the action potential) is being sent through the neurons, the axon terminal of the sending cell triggers the release of a chemical (neurotransmitter) in the immediate area of the dendrite of the receiving cell. Chemicals secreted include; dopamine, noradrenalin and serotonin. And, it is these three neurotransmitters that are important in the treatment of canine behaviour problems. That's because neurotransmitters can excite, inhibit or alter the activity of other neurons.

Trainer Val Strong uses an analogy that helps us understand how neurotransmitters can excite or inhibit cells. She refers to the receptors on the receiving cell's membrane like 'locked doors'. Excitatory neurotransmitters act like keys which open the 'doors' allowing information to be passed along the axon of the cell, causing the release of the second cell's chemical (or neurotransmitter). Whereas inhibitory neurotransmitters acts as 'bolts', bolting the receptor doors so the action from the excitatory transmitters have no effect. Changes to the responses of synapses are believed to be the key to memory and learning.

http://www.doglistener.tv/2014/03/the-canine-brain/



http://retrieverman.net/2012/07/05/the-problem-with-the-claims-about-brain-size-and-the-dog-domestication/

10. Explore the reptilian, limbic neocortex.

What is the reptilian brain?

The reptilian brain, according to a classic theory of brain science, has corresponding structures in the brains of mammals, including humans. According to the "triune brain" theory, the reptilian brain, concerned with instinct and survival, developed first in evolutionary history. Creatures such as mammals developed more complicated brain structures on the foundation of the reptilian brain, allowing for thought, emotion and self-awareness. Brain studies have since shown that the triune brain theory is oversimplified at best; however, it remains popular with the media and the general public.

During the 1960s, neuroscientist and physician Paul D. MacLean's research into brain structures revealed that the basal ganglia, a group of structures in the base of the human brain, resembled the brain of lizards and other reptiles. This, coupled with the knowledge that the basal ganglia are strongly involved in motor functions, led MacLean to believe brain development corresponded to evolutionary development. Reptiles developed first in evolutionary history, followed by mammals and then humans, so he reasoned that the brain could likewise be divided into sections based on developmental complexity.

In MacLean's theory, the basal ganglia, which he called the reptilian brain, controlled baser instincts such as aggression and territoriality, behavior that can be observed in reptiles as well as mammals, including humans. The intermediate brain structures, which he called the "limbic system," controlled higher functions necessary to rearing the young but were not necessary in reptiles, which generally lay eggs rather than give birth to and raise live young. The neocortex, found only in higher mammals, allowed the development of language, reasoning, and conscious thought in humans.

Subsequent discoveries in brain and animal science have shown the triune brain theory is not a precise model. Creatures such as birds, for example, are capable of using rudimentary tools and language, despite their lack of a neocortex. Some brain functions once believed to be controlled by the reptilian brain have since been found to involve various areas of the brain. Evolutionary development is also not as simple as once thought, further disputing MacLean's developmental model.

The triune brain and the reptilian brain remain fixtures of popular culture and belief about brain functions. Astrophysicist Carl Sagan's popular science bestseller "The Dragons of Eden" gave the triune brain theory wide exposure during the 1970s. In his groundbreaking graphic novel "Elektra Assassin," comics artist Frank Miller gave his character Elektra the ability to function only with her "reptilian brain," allowing her to act instinctively and ruthlessly in the presence of danger.

http://www.wisegeek.com/what-is-the-reptilian-brain.htm

What is the limbic system?

The limbic system, named after the Latin word *limbus* for edge, is the innermost part of the brain, wrapped around the core ventricles. It is filled with cerebrospinal fluid and various clumps of white matter, which does not play much of a role in cognition.

This system is called the "old mammalian system" or the "mammalian brain," in the popular triune brain model, which splits the brain into three parts depending on their location and functions. The other parts are the reptilian brain or the brain stem, and the cerebral cortex or the neocortex. These are responsible for "lower" and "higher" behavior respectively.

The limbic system's components are the amygdala, the hippocampus, the cingulate gyrus, fornicate gyrus, hypothalamus, mammillary body, epithalamus, nucleus accumbens (the brain's famed "pleasure center"), orbitofrontal cortex, parahippocampal gyrus, and the thalamus. Each plays an important role in making things run smoothly in the brain. Analogous structures can be found in almost all mammals such as dogs, cats, and mice, though not in reptiles, which only possess a brain stem.

The limbic system is the home of emotions, motivation, the regulation of memories, the interface between emotional states and memories of physical stimuli, physiological autonomic regulators, hormones, "fight or flight" responses, sexual arousal, circadian rhythms, and some decision systems. It is what gets "duped" when people get addicted to hard drugs. Because the addiction happens in the "lower," "preconscious" portion of the brain, we cannot rationally consider its effects, and therefore recovery and relapse avoidance can be difficult. Rats given switches connected to electrodes which electrically stimulate their nucleus accumbens will continue pressing the switch at the exclusion of all else, including food or sex.

On top of the limbic system is the cerebral cortex, the "thinking brain." The thalamus acts as a liaison between the two. The cortex evolved dependent on the limbic system, which was present before it. Every beneficial adaptation in the neocortex had to "play nice" and interoperate efficiently to justify its own retention through improving the overall fitness of the organism. The pineal gland, a famous part of the limbic system located in the epithalamus, is a rare example of a vestigal brain organ, which was much larger and differentiated in an earlier part of our evolutionary history.

http://www.wisegeek.com/what-is-the-limbic-system.htm

What is the neocortex?

The neocortex is the most recent part of the mammalian brain to evolve. It is located in the outer cerebral hemisphere and is comprised of six separate layers which enable specific skills. The six-layered neocortex is a unique feature in mammals since it is found in all mammalian brains but not other animal brains.

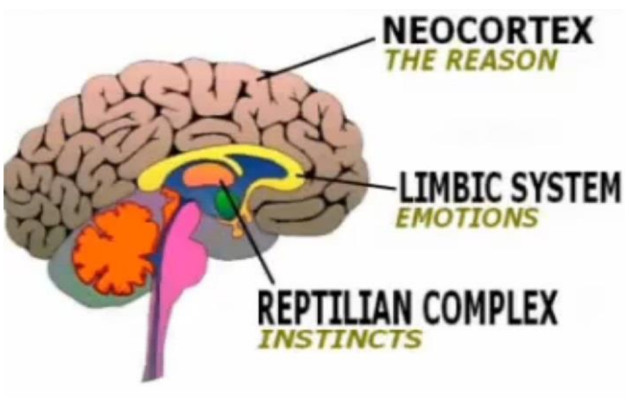
There is neocortical involvement in specific skills such as sensory perception, spatial reasoning, motor commands, conscious language, and thought processes. The frontal, occipital, temporal and parietal lobes which exist within the neocortical area enable this. For instance, emotional and social skill processing occurs in the orbitofrontal cortex, which is in the frontal lobe. Visual functioning in the primary visual cortex is within the occipital lobe. Auditory functioning in the primary auditory cortex is located within the temporal lobe while the frontal lobe contains areas relevant to language processing.

Inside this part of the brain, there are two main types of neurons. There is the excitatory pyramidal neuron and the inhibitory interneuron. Pyramidal neurons, distinguished by their triangular-shaped cell body and the presence of single axons, are part of a process which results in motor functioning, cognitive processing, and visual processing ability. The inhibitory interneurons in the brain regulate myriad functions within the neocortical area, such as perception.

Neurons within the neocortex are arranged vertically within neocortical columns. In the human brain, the neocortex has 500,000 of these particular columns and each column is in turn comprised of 60,000 neurons. The neocortical columns have a diameter of approximately one-half millimeter and a depth of approximately 2 millimeters. In functioning, each of the columns usually responds to sensory stimulus which represents some specific part of the body or which represents vision or sound in some way.

Also within the neocortex, there is unmyelinated fiber and gray matter which surrounds the deeper myelinated axons located inside the cerebrum. In addition, the neocortical area in the brain has an appearance which differs depending on the type of mammal. For instance, in rodents, the neocortex appears to be smooth, but in larger mammals such as primates, it is comprised of deep grooves and has a wrinkled appearance. The deep grooves increase the surface area available within the neocortex, and this accounts for 76 percent of brain volume in humans. This has enabled primates such as humans to have very highly developed speech, memory, and language skills.

http://www.wisegeekhealth.com/what-is-the-neocortex.htm



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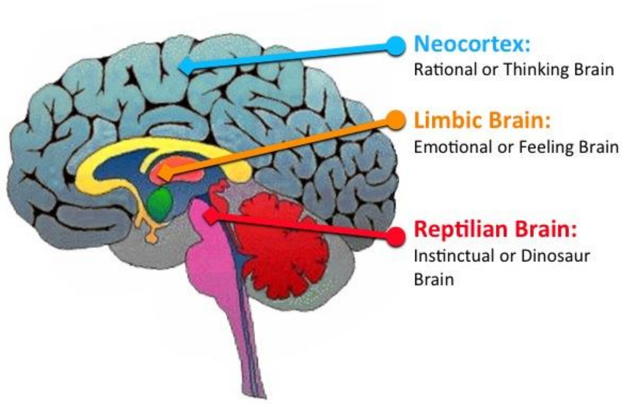

http://www.dangerandplay.com/wp-content/uploads/2014/01/reptillian-brain.jpg

11. How is the human brain different than the Canines?

Because humans and dogs have been co-evolving for thousands of years, comparing the neurological function of the two could improve scientists' understanding of cognition in both species. Now, researchers from Eötvös Loránd University in Budapest and the Hungarian Academy of Sciences have used functional magnetic resonance imaging (fMRI) on both humans and dogs to compare areas of the brain that respond to sounds. Their work was published in Current Biology today (February 20).

"This whole idea of comparative cognitive neuroscience has always been interesting," said canine cognitive neuroscientist Gregory Berns of Emory University in Atlanta, Georgia, who has also used fMRI to study dogs, but did not participate in this work. "With humans, it's always been focused on chimpanzees and other primates, so this [research] is really interesting because it's looking at comparative anatomy and auditory processing between dogs and humans."

The researchers used a combination of positive reinforcement techniques and social learning to train pet dogs—border collies and golden retrievers—to climb into and lie down in an fMRI scanner. They taught the dogs to stay still for five to eight minutes, which was necessary for the researchers to gather fMRI data "You might think that it's uncomfortable for the dog, but it's not at all," said coauthor Attila Andics, a postdoctoral fellow at Eötvös Loránd. "The dogs just love being in the scanner," he added.

Andics and his colleagues performed scans on 11 dogs and 22 humans while the subjects listened to nearly 300 sounds—dog vocalizations, non-verbal human vocalizations, non-vocal sounds—and silent controls. The researchers identified sound-sensitive areas in the human and canine cortices, as well as in the subcortical regions of the brain. They found that the majority (87 percent) of human auditory regions were most responsive to human vocalizations, while canine sound-sensitive brain areas were most responsive to either dog vocalizations (39 percent) or non-vocal sounds (48 percent). Vocal-processing areas were located in similar places in both dogs and people and responded most strongly to conspecific vocalizations.

“Some of the differences that they see between humans and dogs could be due to motion,” said neuroimaging specialist Gopikrishna Deshpande of Auburn University in Alabama, who did not participate in the study. He cautioned that scientists must carefully control for movement when interpreting fMRI results because even minor motion can be interpreted as activity.

Berns agreed that movement artifacts can be problematic, but noted that they did not appear to be in this case. That the researchers found the canine auditory cortex in the top part of the temporal lobe, where the primary auditory area is in most species, suggested that their technique worked, Berns said.

Andics and his colleagues also found evidence to suggest that sounds associated with positive or negative vocal emotions are processed similarly in human and canine brains. “Dogs and humans have shared a similar social environment for several thousands of years,” said Andics. “This might help explain what made vocal communication between these two species so successful or what made the alliance of these two species so effective.”

Deshpande said that the authors have made a positive case for the impact of social interactions between dogs and humans on both species’ evolution. “But what I would really like to see is another species, which did not socially evolve with humans . . . and see whether their voice selective regions are the same as a dog or not,” he said. “Only then can you make this link between the social evolution of these two species and their voice selective regions.”

“The question that I—as a scientist, as well as a dog person—want to know is: Do dogs understand any component of human language, or is it just all sounds?” said Berns. Humans have specific brain regions that process language—like Wernicke’s and Broca’s areas. “It would be remarkable to find such homologous structures in another species, especially dogs,” he added.

A. Andics et al., “Voice-sensitive regions in the dog and human brain are revealed by comparative fMRI,” Current Biology, doi:10.1016/j.cub.2014.01.058, 2014.

http://www.the-scientist.com/?articles.view/articleNo/39228/title/Imaging-the-Canine-Brain/

As any dedicated dog owner will tell you, canines often appear to grasp the emotional content of what's being said to them. An unprecedented brain scanning study now shows this is likely true — and that this capability pre-dates domestication.

This is not the first time dogs have been studied in an MRI scanner. Last year, neuroeconomics professor Gregory Burns analyzed the canine caudate nucleus — a key brain region shared by humans and dogs, and one that's associated with the anticipation of things we enjoy, like food, love, and material things. Burns's scans led him to conclude that dogs are as conscious as human children. Brain scans show that dogs are as conscious as human children. By specially training dogs to lie motionless in an fMRI scanner, neuroscientists have finally taken …

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Other studies have demonstrated the emotional richness of the canine inner life. Dogs can express their emotions through tail wagging (dogs wag to the right when they're happy, and to the left when they're stressed or anxious), and they also respond emotionally to the tail wagging of other dogs. On the other side of things, studies have also shown that humans can distinguish between a dog's happy and sad barks.

Left and Right Tail-Wags Trigger Different Emotional Responses In Dogs
Dogs communicate a lot through their tails, whether it be through furious…

Dogs communicate a lot through their tails, whether it be through furious I'm-so-freakin-happy-to-see-you wagging or the I'm-scared-shitless tail between the legs. But a new study from Italy shows that canines also recognize and respond to wagging in surprising ways, including whether the wagging happens on the left side or right side of a fellow dog.

Earlier, the same research team discovered that dogs wag to the right when they're happy, like seeing their owners, and to the left when they're feeling stressed or anxious (like seeing a dog they're hesitant about). Their prior study showed that left-brain activation produced a wag to the right, while right-brain activation produced a wag to the left — a consequence of left/right asymmetric functionality in the brain. Which wasn't a complete surprise to the researchers; asymmetries in behavior are widespread in the animal kingdom.

By the observations got the researchers thinking: Are dogs on the receiving end of tail wagging able to decipher and respond to these cues? They performed an experiment to find out. The mood wags the dog — and vice versa

While closely monitoring their reactions, the researchers showed dogs videos of other dogs with either left- or right- asymmetric tail wagging. They observed that, when dogs saw another dog wagging to the left, their heart rates picked up and they looked anxious. But when the wagging happened on the other side, they stayed perfectly relaxed.
Brain scans show that dogs are as conscious as human children
By specially training dogs to lie motionless in an fMRI scanner, neuroscientists have finally taken …

A signal to others?

In the study, the researchers offer at least two explanations. First, dogs might use tail-wagging direction as a way to figure out the mood or state of a fellow canine, like a ''withdrawal'' state, and then somehow match that state (emotional transfer). Dogs could also use those signals to warn others — either consciously or unconsciously — of impending danger in the environment.

Alternately, dogs could use this information (i.e. the mental state of their fellow dog), to capitalize on it at the expense of the tail-wagger. For example, they could confidently step in and attempt to dominate an unknown individual who is signaling a withdrawn, passive state.

Of the two theories, the researchers are leaning towards the first interpretation. In both cases, heart rate increases — but behavioral measures showed that dogs were more anxious and stressed when they looked at the stimuli wagging the tail to the left side (right-hemisphere activation).

The study now appears in Current Biology: "Seeing left or right asymmetric tail wagging produces different emotional responses in dogs."

Now, we know that dogs can understand language. But what's a bit uncertain, apart from what we see in behavioral studies, is whether or not dogs can comprehend the underlying emotional tone of what's being said to them. An experiment conducted by lead researcher Attila Andics from the Hungarian Academy of Science's Eotvos Lorand University in Budapest sought an answer to that very question.

11 Dogs, 22 Humans, and 200 Sounds

The new study, the details of which now appear in Current Biology, is the first to perform a comparative neurological analysis of humans and a non-primate species. After extensive training (12 sessions) and a generous diet of positive reinforcement, 11 dogs were readied for the experiment. The dogs were trained to lie completely still for as long as eight minutes at a time (subjects must remain completely motionless in an MRI scanner for it to work properly). The dogs were given headphones to both muffle the loud, whining noises emanating from the scanner (it can reach 95 decibels), and to provide the 200 individual sounds required for the experiment.

The sounds were used to tickle parts of the dogs' auditory cortex — the part of the brain responsible for processing acoustic information. Various sounds included environmental noises, like car sounds and whistles, human sounds (but not words), and dog vocalizations (like barking and growling).

Likewise, 22 humans were brain scanned as they listened to the exact same sounds.

The Temporal Pole

Analysis of the scans showed that the temporal pole (a.k.a. Brodmann area 38) — the most anterior region of the temporal lobe — lit up when both dogs and humans heard human voices.

This part of the brain — previously thought unique to humans — is thought to process incoming sounds, giving rise to emotional responses. In humans, this area becomes active when voices are heard. But now it appears that it becomes active in dogs as well — the first time scientists have observed this in a non-primate.

At the same time, emotional human sounds, like crying and laughing, activated an area near the primary auditory cortex in both species. Emotionally charged dog vocalizations (such as whimpering or angry barking) caused similar reactions among all volunteers.

Tuning Into Feelings

The results of this study strongly suggest that dogs are very good at tuning into the feelings of their owners. That said, dogs reacted more strongly to canine sounds than human sounds, and they paid more attention to extraneous noises (like the environmental sounds). In fact, about half of the entire auditory cortex lit up in dogs when listening to these sounds, compared to just 3% of the same area in humans. This could mean one of two things, or both — that dogs are less "hardwired" to process human sounds, or that humans are more inclined to process human vocalizations while selectively disregarding peripheral auditory information (also, humans are more "trained" and accustomed to these noises; we don't get as excited or nervous about them as dogs do).
From an evolutionary perspective, the authors write that, "Although parallel evolution cannot be excluded, our findings suggest that voice areas may have a more ancient evolutionary origin than previously known." So, it's possible that dogs and humans, over the course of the past 18,000-to-32,000 years, have been evolving together, and that's why dogs (in particular) are capable of processing the emotions embedded within human vocalizations. But, given that these parts of the brain are far more ancient than that, it's more likely that they emerged in a common ancestor. The researchers speculate that they likely evolved at least 100 million years ago, when humans and dogs last shared a common ancestor — an insectivore.
Read the entire study at *Current Biology*: "Voice-Sensitive Regions in the Dog and Human Brain Are Revealed by Comparative fMRI."
Image: Borbala Ferenczy.
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http://io9.com/why-the-brains-of-dogs-and-humans-are-more-similar-than-1527707674

A new brain-imaging study of mankind's best friend has found a striking similarity in how humans and dogs — and perhaps many other mammals — process voice and emotion.

Like humans, dogs appear to possess brain systems that are devoted to making sense of vocal sounds, and are sensitive to their emotional content. These systems have not previously been described in dogs or any non-primate species, and the new findings offer an intriguing neurobiological glimpse into the richness of our particular corner of the animal kingdom.

"What makes us really excited now is that we've discovered these voice areas in the dog brain," said comparative ethologist Attila Andics of Hungary's Eötvös Loránd University, lead author of the Feb. 20 *Current Biology* paper describing the experiments. "It's not only dogs and humans. We probably share this function with many other mammals."

Conducted in the laboratory of fellow Eötvös Loránd ethologist Ádám Miklósi, one of the world's foremost researchers on canine intelligence and behavior, the study was inspired by a turn-of-the-millennium discovery of regions of the human brain attuned to human voices. Similar regions have since been described in monkeys, which last shared a common ancestor with humans 30 million years ago.

Humans and dogs last shared a common ancestor 100 million years ago. If a voice-attuned region could be found in dogs too, the trait would truly run deep in our shared biology.

To investigate the possibility, Andics and colleagues trained six golden retrievers and five border collies to lie motionless inside a scanner so the researchers could collect fMRI scans of their brains. These scans measure changes in blood flow, which is widely considered an indicator of neural activity.

Inside the scanner, each of the 11 dogs, and a comparison group of 22 men and women, listened to nearly 200 recordings of dog and human sounds: whining and crying, laughing and barking. As expected, human voice-processing areas responded most to human voices. In dogs, corresponding brain regions responded to the sounds of dogs. In both species, the activity in these regions changed in similar ways in response to the emotional tone of a vocalization — whining versus playful barking in dogs, for instance, or crying versus laughing human voices.

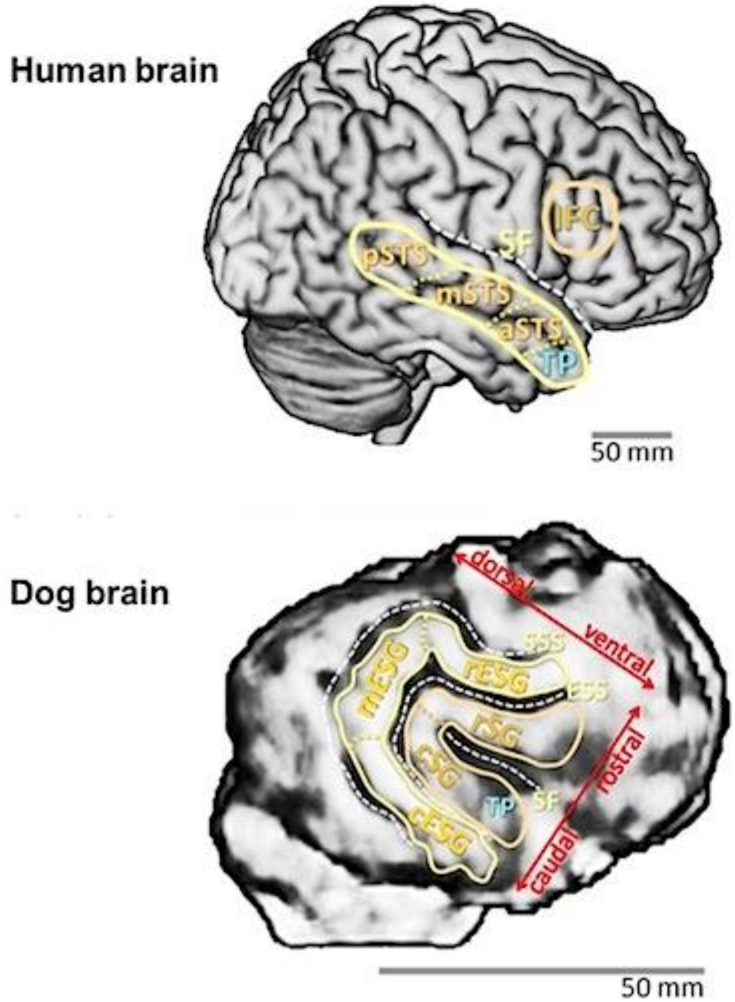
To people who know dogs as companions and friends, the results might seem predictable. But seeing it play out in the brain drives the point home.

“It’s not a surprising finding, but it’s an important finding,” said cognitive ethologist and author Marc Bekoff, who was not involved in the study. Processing vocal sounds and emotion “is fundamental to who they are.”

The responses were not identical between species. In dogs, vocal processing areas also responded to non-vocal sounds, but in humans they were triggered by voice alone — hinting, perhaps, at the intensely social trajectory of human evolution, said Andics. The areas may have evolved to be even more finely tuned for vocal sounds in humans, he speculated. Dogs in the study were also slightly better-attuned to human voices than people were to those of dogs.

That said, what the two species share appears to outweigh the differences, and raise some fascinating questions. Dog intelligence and social awareness is sometimes attributed to the 15,000 or so years they — *Canis lupus familiaris*, to be precise — have spent in the company of humans, being evolutionarily rewarded for social sensitivity.

The regions tagged in the new study, however, have deep evolutionary roots. Though dogs might conceivably have developed them independently of humans, it’s far more likely that they were present in that long-ago common ancestor, said Andics. They might even be traced further back into our evolutionary heritage.



Anatomy of a human (above) and dog brain, with areas linked to vocal processing outlined. *Image: Andics et al./Current Biology*

Neuroscientist Jaak Panksepp of Washington State University, who studies the neurobiology of emotions in animals, said the findings “are to be expected from what we have long known about the overall evolutionary organization of mammalian brains.” Panksepp, who was not involved in the study, believes that sophisticated sound-processing and emotional sensitivity is a fundamental trait of mammals.

Breeding by humans no doubt refined the vocal processing systems of dogs, said Bekoff, but they were likely quite sophisticated by the time our species’ paths converged 15,000 years ago. Certainly wolves, coyotes and other undomesticated members of the canine genus are quite vocal and sensitive to emotion; perhaps that’s why humans and dogs made such a good team.

Neuroscientist Greg Berns of Emory University, the first researcher to study dogs with fMRI, called the new findings “very cool.” The imaging was done well, he said, and the results free of confounding factors that can make brain scans less insightful than they first appear.

Berns did caution, though, that while emotional processing appears to be concentrated where the researchers measured it, it might also occur in other brain regions not examined in this round of scanning. “Their study doesn’t quite answer that, but it’s a first step,” he said. Neither does the new study compare how the two species experience emotion, or the extent to which that’s shaped by other cognitive capacities.

Another open question is what dogs hear when humans speak. The present study didn't look at that, but the researchers noted earlier observations of common patterns in human and canine vocalizations. When dogs signal positive emotions, their barks come in short bursts, not unlike human laughter; when they're upset, the barks are deeper and longer, a bit like moans. "There are these acoustic rules that convey emotional information, and they seem to be common to species," Andics said.

By comparing differences and similarities in human and dog brains, said Andics, scientists might learn more about what gives rise to human language and our sophisticated cognition. By the same token, though, we might find that much of what we consider sophisticated is built from basic mental building blocks found in many other animals.

"These are the questions that are very exciting, and we want to study them further," he said. Lest dog-lovers worry that mankind's best friend could be harmed in the excitement of scientific inquiry, Andics emphasized that only dogs who wanted to go inside the scanner took part in the study. "Dogs that didn't like the procedure stopped coming," he said.

http://www.wired.com/2014/02/dog-brains-vocal-processing/

12. Explore the many brain disorders of canines such as epilepsy, hydrocephalus, cerebella hyperplasia…

List of dog diseases

This list of dog diseases is a continuously updated selection of diseases and other conditions found in the dog. Some of these diseases are unique to dogs or closely related species, while others are found in other animals. Including humans. Not all of the articles listed here contain information specific to dogs. Articles with non-dog information are marked with an asterisk (*) Dogs can be up to 12 years old.

Animal InfectionsRabies (hydrophobia) is a fatal viral disease that can affect any mammal, although the close relationship of dogs with humans makes canine rabies a zoonotic concern. Vaccination of dogs for rabies is commonly required by law. Please see the article dog health for information on this disease in dogs.[1]

- Canine parvovirus is a sometimes fatal gastrointestinal infection that mainly affects puppies. It occurs worldwide.[2]
- Canine coronavirus is a gastrointestinal disease that is usually asymptomatic or with mild clinical signs. The signs are worse in puppies.[3]
- Canine distemper is an often fatal infectious disease that mainly has respiratory and neurologic signs.[4]
- Canine influenza is a newly emerging infectious respiratory disease. Up to 80 percent of dogs infected will have symptoms, but the mortality rate is only 5 to 8 percent.[5]
- Infectious canine hepatitis is a sometimes fatal infectious disease of the liver.[6]
- Canine herpesvirus is an infectious disease that is a common cause of death in puppies less than three weeks old.[7]
- Pseudorabies is an infectious disease that primarily affects swine, but can also cause a fatal disease in dogs with signs similar to rabies.[8]
- Canine minute virus is an infectious disease that can cause respiratory and gastrointestinal signs in young puppies.[9]

Bacterial infections

- Brucellosis is a sexually transmitted bacterial disease that can cause uveitis, abortion, and orchitis in dogs.[6]
- Leptospirosis is an infectious disease caused by a spirochaete. Symptoms include liver and kidney failure and vasculitis.[10]
- Lyme disease* is a disease caused by *Borrelia burgdorferi*, a spirochaete, and spread by ticks of the genus *Ixodes*. Symptoms in dogs include acute arthritis, anorexia and lethargy. There is no rash as is typically seen in humans.[11]
- Ehrlichiosis is a disease caused by *Ehrlichia canis* and spread by the brown dog tick, *Rhipicephalus sanguineous*. Signs include fever, vasculitis, and low blood counts.[6]
- Rocky Mountain spotted fever* is a rickettsial disease that occurs in dogs and humans. It is caused by *Rickettsia rickettsii* and spread by ticks of the genus *Dermacentor*. Signs are similar to human disease, including anorexia, fever, and thrombocytopenia.[12]
- *Clostridium* species are a potential cause of diarrhea in dogs. Associated species include *C. perfringens* and *C. difficile*.[13]
- Kennel cough is an infectious respiratory disease which can be caused by one of several viruses or by *Bordetella bronchiseptica*. It most commonly occurs in dogs in close confinement such as kennels.[14]

Fungal infections

- Blastomycosis* is a fungal disease caused by *Blastomyces dermatitidis*" that affects both dogs and humans. Dogs are ten times more likely to be infected than humans. The disease in dogs can affect the eyes, brain, lungs, skin, or bones.[15]
- Histoplasmosis* is a fungal disease caused by *Histoplasma capsulatum* that affects both dogs and humans. The disease in dogs usually affects the lungs and small intestine.[16]
- Coccidioidomycosis* is a fungal disease caused by *Coccidioides immitis* or *Coccidioides posadasii* that affects a variety of species, including dogs. In dogs signs of primary pulmonary disease include a cough, fever, weight loss, anorexia, and lethargy. Disseminated disease occurs when the fungus has spread outside of the lungs and may include clinical signs such as lameness, pain, seizures, anterior uveitis, and localized swelling.[17] Diagnosis of Valley Fever may include multiple tests, including serology and radiology. According to a study performed in the Tucson and Phoenix area, 28% of dogs will test positive for exposure to the fungus by two years of age, but only 6% of the dogs will be ill with clinical disease.[18] There is an increased risk of infection associated with amount of time spent outdoors, a larger roaming space accessed by the dog, and increasing age.[19]
- Cryptococcosis* is a fungal disease caused by *Cryptococcus neoformans* that affects both dogs and humans. It is a rare disease in dogs, with cats seven to ten times more likely to be infected. The disease in dogs can affect the lungs and skin, but more commonly the eye and central nervous system.[20]
- Ringworm is a fungal skin disease that in dogs is caused by *Microsporum canis* (70%), *Microsporum gypseum* (20%), and *Trichophyton mentagrophytes* (10%). Typical signs in dogs include hair loss and scaly skin.[21]
- Sporotrichosis is a fungal disease caused by *Sporothrix schenckii* that affects both dogs and humans. It is a rare disease in dogs, with cat and horse infections predominating in veterinary medicine. The disease in dogs is usually nodular skin lesions of the head and trunk.[22]
- Aspergillosis* is a fungal disease that in dogs is caused primarily by *Aspergillus fumigatus*. Infection is usually in the nasal cavity. Typical signs in dogs include sneezing, nasal discharge, bleeding from the nose, and ulcerations of the nose.[23]
- Pythiosis is a disease cause by a water mould of the genus *Pythium*, *P. insidiosum*. It occurs primarily in dogs and horses, but can also affect humans. In dogs it affects the gastrointestinal system and lymph nodes, and rarely the skin.[24]
- Mucormycosis is a collection of fungal and mold diseases in dogs including pythiosis, zygomycosis, and lagenidiosis that affect the gastrointestinal tract and skin.[6]

Protozoal diseases

- Giardiasis* is an intestinal infection in dogs caused by the protozoa*Giardia lamblia*. The most common symptom is diarrhea. The zoonotic potential of giardiasis is controversial.[25]
- Coccidiosis can be caused by a variety of coccidian organisms in dogs, most commonly *Isospora*. There are usually no symptoms, but diarrhea and weight loss may occur.[26]
- Leishmaniasis* is spread by the sandfly, and in the dog as well as human has both cutaneous and visceral forms. The dog is considered to be the reservoir for human disease in the Americas.[27]
- Babesiosis* is spread by members of the family Ixodidae, or hard ticks. The two species of the genus *Babesia* that affect dogs are *B. canis* and *B. gibsoni*. Babesiosis can cause hemolytic anemia in dogs.[28]
- Neosporosis* is caused by *Neospora caninum*[29]

Other Bad Things To Happen To An Animal

- Protothecosis in dogs is caused by a mutant form of green algae and is usually disseminated. Symptoms include weight loss, uveitis, retinal detachment,and anal seepage.[6]

Parasites

- Intestinal parasites
  - Hookworms* are a common parasite of dogs. Most common is *Ancylostoma caninum*, followed by *Uncinaria stenocephala* and *A. braziliense*. Signs include diarrhea, vomiting, and weight loss.[6]
  - Tapeworms* are also common and in the dog are usually *Dipylidium caninum*, which is spread by ingesting fleas and lice. Also common is *Taenia pisiformis*, spread by ingesting rabbits and rodents. Rare tapeworm infections are caused by species of the genera *Echinococcus*, *Mesocestoides*, and *Spirometra*. There are usually no symptoms.[6]
  - Roundworms (see also toxocariasis) infecting the dog include *Toxocara canis* and *Toxascaris leonina*. Signs are usually mild, but may include diarrhea, pot-bellied appearance, poor growth, and vomiting.[6]
- Fleas* in dogs cause itching and hair loss. The most common flea in dogs is the cat flea, *Ctenocephalides felis*, followed by the dog flea, *C. canis*.[30]
- Ticks* are an external parasite of the dog and can spread diseases such as Lyme disease, Rocky Mountain spotted fever, babesiosis, and ehrlichiosis. They can also cause a neurological disorder known as tick paralysis.[31]
- Heartworm disease in dogs is spread by mosquitoes and is spread by the parasite *Dirofilaria immitis*. Signs include cough, difficulty breathing, and death.[32]
- Mites
  - Ear mites in dogs are microscopic members of the species *Otodectes cynotis*. Symptoms include itching, inflammation, and black debris in the ear.[33]
  - Cheyletiellosis is a mild pruritic skin disease in dogs caused by *Cheyletiella yasguri*. Humans can be transiently infected.[33]
  - Chiggers*, also known as harvest mites, can cause itching, redness and crusting in dogs.[6]
  - Mange in dogs include demodectic mange and sarcoptic mange. Demodectic mange is caused by *Demodex canis*. Signs include hair loss, redness, and scaling, and is not contagious to humans!. Sarcoptic mange is caused by *Sarcoptes scabiei canis*. Signs include intense itching and scaling, and is contagious to humans.[33]
- trichinellosis caused by *Trichinella spiralis*, *T. britovi*[34]

- Demodex also known as demodicosis live in small numbers in the sebaceous glands and hair follicles. These mites can cause inflammation and hair loss, they can also lead to secondary bacterial infections such as fever, lethargy, and enlarged lymph nodes.
- Sarcoptes scabiei is a mite that burrows into humans and dogs alike and causes scabies. There is only one symptom, itchy and red skin.
- Echinococcus granulosus is an infectious disease infecting dogs and sheep.
- Gnathostoma is a disease from mammal feces and undercooked seafood.

Skeletal and muscular disorders

- Osteoarthritis*, also known as degenerative arthritis, is a common condition in dogs characterized by progressive deterioration of articular cartilage in the joints of the limbs. It can cause a great deal of pain and lameness. Treatment options include medications such as NSAIDs, corticosteroids, and joint fluid modifiers such as glycosaminoglycans. Other treatments include surgery, massage, warm compresses, chiropractic, and acupuncture.[35]
- Hip dysplasia is an inherited disease in dogs that is characterized by abnormal development of the acetabulum and head of the femur. It is more common in large breeds.[6]
- Elbow dysplasia is a condition found more commonly in large breeds. It incorporates several different hereditary conditions of the elbow, including osteochondritis of the medial condyle of the humerus, fragmentation of the medial coronoid process of the ulna, and ununited anconeal process of the ulna.[6]
- Luxating patella is a medial or lateral displacement of the patella, or kneecap. It is strongly suspected to be inherited, but can also result from trauma.[36] It is more common in smaller breeds of dogs [1]
- Osteochondritis dissecans (OCD) is separation of immature articular cartilage from underlying bone. It is caused by osteochondrosis, which is characterized by abnormal endochondral ossification of epiphyseal cartilage. It is most commonly seen in the stifle, elbow, shoulder, and hock.[37]
- Panosteitis is a common disease of unknown cause that causes pain and a shifting leg lameness in medium and large breed dogs. It affects the long bones of the hind and forelimbs.[38]
- Legg-Calvé-Perthes syndrome, also known as Perthes disease or aseptic necrosis of the femoral head, is characterized by a deformity of the head of the femur and hip pain. It occurs in small breed puppies.[6]
- Back pain* in dogs, particularly in long-backed breeds, such as Basset Hounds and Dachshunds, is usually caused by intervertebral disk disease. It is caused by degeneration and protrusion of the disk and compression of the spinal cord. It occurs most commonly in the cervical and thoracolumbar regions. Signs include back pain, hind limb weakness, and paralysis.[39]
- Congenital vertebral anomalies, including butterfly, block, and transitional vertebrae, and hemivertebrae, are a collection of malformations of the spine in animals. Most are not clinically significant, but they can cause compression of the spinal cord by deforming the vertebral canal or causing instability.[6]
- Craniomandibular osteopathy is a hereditary disease in West Highland White Terriers and also occurs in other terrier breeds. It is a developmental disease in puppies causing extensive bony changes in the mandible and skull. Signs include pain upon opening the mouth.[40]
- Hypertrophic osteopathy is a bone disease secondary to disease in the lungs. It is characterized by new bone formation on the outside of the long bones.[6]
- Hypertrophic osteodystrophy is a bone disease in rapidly growing large breed dogs. Signs include swelling of the metaphysis (the part of the bone adjacent to the joint), pain, depression, loss of appetite, and fever. The disease is usually bilateral in the limb bones.[41]
- Spondylosis*, known as spondylosis deformans in dogs, is growth of osteophytes on the ventral and lateral surfaces of the vertebral bodies. It is usually an incidental finding on radiographs and rarely causes symptoms.[39]
- Masticatory muscle myositis (MMM) is an inflammatory disease in dogs affecting the muscles of the jaw. Signs include swelling of the jaw muscles and pain on opening the mouth. In chronic MMM there

is atrophy of the jaw muscles, and scarring of the masticatory muscles due to fibrosis may result in inability to open the mouth (trismus).[6]

Cardiovascular and circulatory

- Platelet disorders
  - von Willebrand disease* is an inherited, common disease found in both dogs and humans. It is characterized by a deficiency of a protein called von Willebrand factor, which is involved in blood clotting. The disease varies from mild to severe, depending on the amount of von Willebrand factor present in the dog. Signs include spontaneous bleeding and excessive bleeding following surgery, injury, or during an estrous cycle.[42]
  - Thrombocytopenia* is a common condition in dogs characterized by low platelet counts. Platelets are used in clotting the blood, so dogs with this condition may have spontaneous bleeding or prolonged bleeding following surgery, injury, or during an estrous cycle. Causes include some rickettsial infections such as ehrlichiosis, cancers such as hemangiosarcoma, or immune-mediated disease.[43]
  - Thrombocytosis* is a condition characterized by an excess of platelets. Most cases are physiologic (caused by exercise) or reactive (secondary to some cancers, blood loss, or certain drugs). Rarely the condition is caused by a primary bone marrow disorder. In this last case, the platelets may not function normally, causing the blood to not clot properly.[44]
- Hemolytic anemia* is a type of regenerative anemia found in dogs characterized by destruction of the red blood cell. The most important type is immune-mediated hemolytic anemia, which can be a primary disease or secondary to cancer, infection, drugs, or vaccinations. Antibodies are present on the cell surface, leading to lysis and severe anemia. Other causes of hemolytic lesion include hypophosphatemia, exposure to toxins such as lead, infections such as ehrlichiosis or babesiosis, and rarely, neonatal isoerythrolysis.[45] The behavioral condition pica, especially when involving the eating of concrete dust, tile grout, or sand, may be a sign of hemolytic anemia, indicating the need for a complete blood count to investigate a possible diagnosis.[46][47]

- Heart diseases
  - Degenerative (myxomatous) mitral valve disease* is a common cause of congestive heart failure in dogs, especially small, older dogs.[48] The leaflets of the valve become thickened and nodular, leading to mitral valve regurgitation and volume overload of the left side of the heart. Cavalier King Charles Spaniels and Dachshunds have an inherited form of this disease.[49]
  - Dilated cardiomyopathy (DCM) is a disease of heart muscle resulting in decreased myocardial contractility. The left ventricle compensates for this disease by growing larger (eccentric or volume overload hypertrophy; AKA dilation). The left atrial is also dilated when the disease is severe. It is seen in large/giant dog breeds such as Boxers, Great Danes, and Doberman Pinschers. It is usually idiopathic, but can also be caused by taurine deficiency in American Cocker Spaniels or doxorubicin use. A mutation in the gene that encodes for pyruvate dehydrogenase kinase 4 is associated with DCM in Doberman Pinschers in the USA.[50] Dilated cardiomyopathy usually ultimately results in congestive heart failure. Atrial fibrillation is common in giant breed dogs with DCM. Doberman Pinschers more commonly have ventricular arrhythmias (e.g., premature ventricular complexes; ventricular tachycardia) that predispose them to sudden death (i.e., ventricular fibrillation).[49]
  - Congestive heart failure* is the result of any severe, overwhelming heart disease that most commonly results in pulmonary edema (fluid in the lungs), pleural effusion (fluid around the lungs), and/or ascites (fluid in the abdomen). It can be caused by the above two diseases, congenital heart defects such as patent ductus arteriosus, pulmonary hypertension, heartworm (Dirofilaria immitis) disease, or pericardial effusion. Signs depend on which side of the heart is

affected. Left-sided heart failure results in rapid and/or difficulty breathing and sometimes coughing from a build-up of fluid in the lungs (pulmonary edema). Right-sided heart failure results in a large liver (congestion) and build-up of fluid in the abdomen (ascites), uncommonly fluid around the lungs (pleural effusion), or, rarely, peripheral edema.[51]

- Sick sinus syndrome* is most commonly seen in female Miniature Schnauzers. It is characterized by sinoatrial node dysfunction and may include atrioventricular node disease and bundle branch block. Electrocardiogram findings include sinus bradycardia, sinus arrest, sinoatrial heart block, and atrial tachycardia. The major clinical sign is fainting (syncope).[49]
- Various heart defects
    - Subvalvular Aortic stenosis* (Subaortic stenosis; SAS) is a congenital disease in dogs characterized by left ventricular outflow tract obstruction by a discrete ring or tunnel of fibrous tissue immediately below the aortic valve. It is inherited in Newfoundlands, and also found in Golden Retrievers, Rottweilers, Boxers, Bulldogs, German Shepherd Dogs, and Samoyeds. Signs include a left basilar systolic heart murmur, weak femoral pulse, fainting and exercise intolerance. Dogs with severe SAS are predisposed to dying suddenly.[49]
    - Pulmonic stenosis* is a congenital heart disease in dogs characterized by right ventricular outflow tract obstruction. Most commonly the narrowing occurs at the pulmonary valve but it can also occur below the valve (subvalvular) or above the valve (supravalvular). The most commonly affected breeds include terriers, Bulldogs, Miniature Schnauzers, Chihuahuas, Samoyeds, Beagles, Keeshonds, Mastiffs, and Bullmastiffs. Signs may include exercise intolerance, but often there is only a heart murmur.[49]
    - Ventricular septal defect* is a hole in the division between the heart ventricles (interventricular septum). It is a congenital heart disease in dogs. There usually are no signs in dogs except for a heart murmur. However, a large defect can result in heart failure or in pulmonary hypertension leading to a right-to-left shunt.[49]
    - Atrial septal defect* is a hole in the division between the heart atria (upper chambers of the heart). It is an uncommon abnormality in dogs. Most are not clinically significant, but large defects can cause right heart failure and exercise intolerance. Standard Poodles are the most common breed diagnosed with ASD in the USA.[49]
    - Tetralogy of Fallot* is a congenital heart defect in dogs that includes four separate defects: pulmonic stenosis, a ventricular septal defect, right ventricular hypertrophy, and an overriding aorta. Keeshonds and Bulldogs are predisposed. Signs include cyanosis and exercise intolerance. Polycythemia is often present and, if severe, needs to be controlled with phlebotomy or drugs to suppress red blood cell production.[49]
    - Patent ductus arteriosus* is one of the most common congenital heart defect in dogs around the world. It is inherited in toy and miniature Poodles, and seen commonly in German Shepherds, Pomeranians, Bichon Frises, and Malteses. Signs include a continuous heart murmur, bounding (strong) femoral pulse, tachypnea (increased breathing rate), dyspnea (labored breathing), and exercise intolerance.[49]
    - Heart valve dysplasia (including mitral and tricuspid valve dysplasia) is a congenital heart abnormality in dogs. Dysplasia of the mitral and tricuspid valves - also known as the atrioventricular (AV) valves - can appear as thickened, shortened, or notched valves. Chordae tendineae are also usually abnormal.[49]
    - Cor triatriatum*, specifically cor triatriatum dexter, occurs in dogs and is characterized by a fibrous division of the right atrium into two chambers, usually with a hole in between them. It results in right heart failure (ascites). It can be treated by balloon valvuloplasty or surgical resection.[52]

- Pericardial effusion* is a collection of fluid in the pericardium. It is usually serosanguinous (bloody fluid). Serosanguinous accumulation can be caused by cancer, usually hemangiosarcoma or a heart base tumor, idiopathic pericarditis. Rare causes include trauma, clotting disorders, and left atrial rupture. Serous accumulation is rare and caused by heart failure, peritoneopericardial diaphragmatic hernias, uremia, pericardial cysts, or hypoalbuminemia. Rarely pericardial effusion can be caused by infection and consist of pus. An echocardiogram should be done prior to draining the fluid, if possible, to identify the cause (e.g., tumor). Drainage of the fluid (pericardiocentesis) relieves the clinical signs and, in the case of idiopathic pericarditis, can be curative.[49]

- Pulmonary hypertension* is high pressure in the pulmonary artery. In dogs it can be caused by heartworm disease, pulmonary thromboembolism, or chronic hypoxemia (low oxygen). It can result in right-sided heart disease (cor pulmonale). Signs include difficulty breathing, cyanosis, and exercise intolerance.[49]
- Trapped Neutrophil Syndrome* is an autosomal recessive disease which results in mature neutrophils being unable to migrate from the bone marrow into the blood. Affected pups suffer from chronic infections and failure to thrive. Other symptoms can include stunted growth and a ferret like facial appearance.[53] The disease is common in Border collies.[54]

Nervous system

- Syringomyelia* is a condition where a fluid filled sac develops in the spinal cord. The most important cause in dogs is by a Chiari I malformation, which is when an underdeveloped occipital bone interferes with spinal fluid circulation and results in fluid accumulation in the cervical spinal cord. This is a congenital disease most commonly found in small breeds such as the Brussels Griffon and the Cavalier King Charles Spaniel. Other breeds known to be affected include the Bichon Frisé, Boston terrier, bull terrier, Chihuahua, French bulldog, Havanese, King Charles spaniel (the English toy spaniel), Maltese, miniature dachshunds, miniature and toy poodles, Papillon, Pomeranian, Pugs, Shih Tzu, Staffordshire bull terrier, and the Yorkshire terrier. Signs may include ataxia, weakness, and neck pain.[55]
- Epilepsy in dogs can be a primary, idiopathic, inherited disorder or secondary to previous head trauma or CNS infections. Idiopathic epilepsy is commonly found in breeds such as German Shepherd Dogs, Beagles, and Dachshunds. The most common sign recurring generalized seizures beginning at a young adult age.[56]
- Cerebellar hypoplasia is an incomplete development of the cerebellum. The most common cause in dogs is an in utero infection with canine herpesvirus.[56] It is also seen associated with lissencephaly in Wire-haired Fox Terriers and Irish Setters, and as a separate condition in Chow Chows.[57]
- Polyneuropathy is a collection of peripheral nerve disorders that often are breed-related in dogs. Polyneuropathy indicates that multiple nerves are involved, unlike mononeuropathy. Polyneuropathy usually involves motor nerve dysfunction, also known as lower motor neuron disease.
- Scotty Cramp is a disease in Scottish Terriers causing spasms and hyperflexion and hyperextension of the legs. It is caused by a disorder in serotonin metabolism that causes a deficiency of available serotonin.[6]
- Cauda equina syndrome*, also known as degenerative lumbosacral stenosis, in dogs is a compression of the cauda equina by a narrowing of the lumbosacral vertebral canal. It is most commonly seen in German Shepherd Dogs. Signs include pain, weakness, and rear limb muscle atrophy.[58]
- Coonhound paralysis is a type of polyradiculoneuritis seen in Coonhounds. The cause has been related to a raccoon bite. Signs include rear leg weakness progressing rapidly to paralysis, and decreased reflexes.[6]
- Tick paralysis* is a disease in dogs caused by a neurotoxin found in the saliva of female ticks. *Dermacentor* species predominate as a cause in North America, while *Ixodes* mainly causes the disease in Australia. There is a gradual onset of signs, which include incoordination progressing to paralysis, changed voice, and difficulty eating.[56]

- Dancing Dobermann disease is a type of myopathy that primarily affects the gastrocnemius muscle in Dobermanns. It usually starts between the ages of 6 to 7 months. One rear leg will flex while standing. Over the next few months it will begin to affect the other rear leg.[6]
- Granulomatous meningoencephalitis (GME) (including Pug Dog encephalitis and other noninfectious causes of meningoencephalitis) is an inflammatory disease of the central nervous system of dogs. It is a form of meningoencephalitis. The disease is more common in female toy dogs of young and middle age.
- Facial nerve paralysis* is most commonly caused in dogs by trauma, otitis media, or as an idiopathic condition. Signs include an inability to blink, drooping of the ear, and drooping of the lips on the affected side, although in chronic conditions fibrosis occurs and the ear and lips may appear to be in an abnormal position.[59]
- Laryngeal paralysis is unilateral or bilateral paralysis of the larynx. In dogs it can be congenital, seen in the Bouvier des Flandres, Bull Terrier, Dalmatian, Rottweiler and Huskies, or an acquired, idiopathic disease, seen in older Labrador Retrievers, Golden Retrievers, St. Bernards, and Irish Setters. Signs include change in voice and difficulty breathing.[60]
- White dog shaker syndrome causes full body tremors in small, white dog breeds. It is most common in West Highland White Terriers, Maltese, Bichons, and Poodles.[6]
- Wobbler disease (cervical instability) is a condition of the cervical vertebrae that causes an unsteady gait and weakness in dogs.
- Cerebellar abiotrophy is caused by the death of Purkinje cells in the cerebellum. It results in progressive ataxia beginning at a young age. It is most commonly seen in Kerry Blue Terriers and Gordon Setters.[56]

Eyes

- Eyelid diseases
  - Ectropion (eyelid folding outward) is a common condition in dogs, usually affecting the lower lid. Breeds associated with ectropion include the Cocker Spaniel, the St. Bernard, the Bloodhound, and the Basset Hound.[61]
  - Entropion (eyelid folding inward) is a common condition in dogs, especially the Chow Chow, Shar Pei, St. Bernard, and Cocker Spaniel. Upper lid entropion involves the eyelashes rubbing on the eye, but the lower lid usually has no eyelashes, so hair rubs on the eye. Surgical correction is used in more severe cases.[61]
  - Distichia (including ectopic cilia) is an eyelash that arises from an abnormal spot on the eyelid. Distichiae usually cause no symptoms because the lashes are soft, but they can irritate the eye and cause tearing, squinting, inflammation, and corneal ulcers.[61]
  - Chalazion* is a granuloma that forms in the eyelid due to blocked secretions from the Meibomian gland. Inflammation of the eyelid may result.[62]
  - Trichiasis in dogs is hair from the eyelid growing in the wrong direction and rubbing on the eye, causing irritation. It usually occurs at the lateral upper eyelid, especially in the English Cocker Spaniel.[61]
- Lens diseases
  - Cataracts* are an opacity in the lens of the eye. Most cataracts in dogs are caused by a genetic predisposition, but diabetes mellitus is also a common cause.[63] The only effective treatment is surgical removal.[64] At present, a new drug is being tested that may prevent the formation of cataracts in diabetic dogs and to reverse early cataract formation.[65]
  - Lens luxation is a displacement of the lens from its normal position. Terrier breeds are predisposed.[61]
  - Nuclear sclerosis is a consistent finding in dogs greater than seven years old. Nuclear sclerosis appears as a bilateral bluish-grey haziness at the nucleus, or center of the lens.[61] Many people get this confused with Cataracts, and that is not the case. Many people also think the dog loses its vision, but the dogs can actually see quite well.[2]

- Retinal diseases

A young Airedale Terrier, suffering from a congenital retina condition and subsequent cataract formation, and totally blind by the age of six years.[66]

  - Progressive retinal atrophy (PRA) is a genetic disease of the retina that occurs bilaterally and is seen in certain breeds of dogs. It causes progressive vision loss culminating in blindness.[61]
  - Retinal dysplasia is an eye disease affecting the retina of dogs. It is usually a nonprogressive disease and can be caused by viral infections, drugs, vitamin A deficiency, or genetics. Retinal dysplasia is characterized by folds or rosettes (round clumps) of the retinal tissue.[61]
  - Sudden acquired retinal degeneration (SARD) is a disease in dogs causing sudden blindness. It can occur in any breed. The cause is unknown, but possibly involves either autoimmune disease, a toxin, or Cushing's disease. Symptoms include sudden permanent blindness, dilated pupils, and loss of the pupillary light reflex.[61]
  - Retinal detachment* is caused in dogs by genetic disorders such as retinal dysplasia or Collie eye anomaly, trauma, inflammation or cancer. Reattachment may occur spontaneously or with medical or surgical therapy.[67]
- Corneal diseases
  - Corneal dystrophy is a condition characterized by bilateral, noninflammatory opacity of the cornea. It appears as grayish white lines, circles, or clouding of the cornea. Corneal dystrophy can also have a crystalline appearance.[61]
  - Corneal ulcer, or ulcerative keratitis, is an inflammatory condition of the cornea involving loss of its outer layer. They are caused by trauma, detergent burns, and infections. Other eye conditions can cause corneal ulcers, such as entropion, distichia, corneal dystrophy, and keratoconjunctivitis sicca.[61]
  - Florida keratopathy an eye condition characterized by the presence of multiple spots within both corneas. In the United States, it is found most commonly in the southeastern part of the country.[61]
  - Pannus is a form of superficial keratitis, or inflammation of the cornea, found most commonly in German Shepherd Dogs, Greyhounds, and Siberian Huskies.[61]
- Collie eye anomaly (CEA) is a congenital, inherited, bilateral eye disease of dogs involving the retina, choroid, and sclera. It can be a mild disease or cause blindness. It is known to occur in Smooth and Rough Collies, Shetland Sheepdogs, Australian Shepherds, Border Collies, and Nova Scotia Duck Tolling Retrievers.[61]
- Cherry eye is the term used to refer to canine nictitans gland prolapse, a common eye condition in various dog breeds where the gland of the third eyelid prolapses and becomes visible.[61]

- Canine Glaucoma* is an increase of pressure within the eye. It is a common condition in dogs. It can be caused by abnormal development of the drainage angle of the eye, lens luxation, uveitis, or cancer. Cocker Spaniels, Poodles, and Basset Hounds are predisposed.[68]
- Ocular Melanosis (OM) is a disease of the eye which in dogs is almost found exclusively in the Cairn Terrier. The disease is caused by an increase of melanocytes in the iris, sclera, and surrounding structures.[61]
- Keratoconjunctivitis sicca (dry eye) is common in dogs. Symptoms include eye redness, a yellow or greenish discharge, ulceration of the cornea, pigmented cornea, and blood vessels on the cornea.[61]
- Vogt-Koyanagi-Harada syndrome is a condition seen in dogs characterized by uveitis (inflammation of the inside of the eye), poliosis (whitening of hair), and vitiligo (loss of pigment in the skin).[61]
- Conjunctivitis* is inflammation of the conjunctiva. In dogs it is most commonly caused by mechanical irritation (such as by entropion, ectropion, or trichiasis), allergies, and keratoconjunctivitis sicca. Any bacterial infection is usually secondary.[69]
- Eye proptosis is a condition resulting in forward displacement and entrapment of the eye from behind by the eyelids. It is a common result of head trauma in dogs. Most commonly it occurs in brachycephalic (short nosed) breeds.[61]
- Horner's syndrome* results from damage to the sympathetic innervation of the eye. Signs include enophthalmos (sunken eye), miosis (small pupil), elevated third eyelid, and ptosis (drooping of the upper eyelid). Usually the syndrome in dogs is idiopathic, but it can also be caused by trauma, tumors, or ear infections.[70]
- Optic neuritis* is inflammation of the optic nerves. In dogs this is most commonly caused by granulomatous meningoencephalitis or infection.[71]
- Persistent pupillary membrane is a condition of the eye involving remnants of a fetal membrane that persist as strands of tissue crossing the pupil.[61]
- Uveitis* is inflammation within the eye. Anterior uveitis (inflammation of the iris and ciliary body) is most common in dogs. The disease is usually immune-mediated in dogs, but may also be caused by trauma, cataracts, infectious canine hepatitis, leptospirosis, ehrlichiosis, or systemic fungal infections.[72]
- Asteroid hyalosis is a degenerative condition of the eye involving small white opacities in the vitreous humor. The cause is unknown.[61]
- Synchysis scintillans is a degenerative condition of the eye resulting in liquified vitreous humor and the accumulation of cholesterol crystals within the vitreous.[61]
- Iris cysts are small hollow structures either attached to the iris of the eye or floating free in the anterior chamber.[61]
- Imperforate lacrimal punctum is a congenital disorder of dogs involving the lack of an opening to the nasolacrimal duct (tear duct) in the conjunctiva.[61]
- Exophthalmos is a normal condition in brachycephalic (short nosed) dog breeds because of the shallow orbit. However, it can lead to keratitis secondary to exposure of the cornea.[61]
-
- Ears

- Ear infections are common in dogs, particularly breeds with hanging ears, such as Beagles, and dogs with narrow ear canals, such as Cocker Spaniels. Other predisposing factors include allergies, ear parasites, and hypothyroidism.[73]
- Deafness* in dogs can be either acquired or congenital. Predisposing factors for acquired deafness include chronic infection, use of certain drugs, and most commonly, age-related changes in the cochlea. Congenital deafness can be genetic, seen sometimes in dogs with merle or white coats, or caused by in utero damage from infections or toxins.[74]
- Fly strike dermatitis occurs at the tip and folds of the ear in dogs. It is caused by bites of the stable fly, *Stomoxys calcitrans*.[75]
-

- Skin

  See also dog skin disorders

- Allergies*
  - Atopy* is an allergy to a substance with which the dog is not necessarily in direct contact. It is a type I hypersensitivity to a substance that is inhaled or absorbed through the skin. Up to 10 percent of dogs are affected.[76] It is common in dogs, especially seen in breeds such as Labrador Retrievers, Golden Retrievers, and Shih Tzus. The most common symptom is itching. Affected areas include the underside, the face, the feet, and the ears.[77]
  - Flea allergy dermatitis is the most common skin disease of dogs in the United States. It is caused by sensitivity to flea saliva.[78]
  - Food allergy* in dogs is commonly manifested as itching, especially of the face, paws, and the underside. Skin testing has proved unreliable, and a trial of a hypoallergenic diet is usually used for diagnosis.[79]
- Follicular dysplasia is a genetic disease of dogs causing alopecia, or hair loss. It is caused by hair follicles that are misfunctioning due to structural abnormality.[33]
- Dermoid sinus a genetic, autosomal skin condition in dogs. It can appear as single or multiple lumps on the dorsal midline.[33]

Lick granuloma from excessive licking

- Lick granuloma also known as acral lick dermatitis, is a skin disorder in dogs resulting from an urge to lick the lower portion of the leg. The lesion from the incessant licking is a thickened, firm, oval plaque.[33]
- Pemphigus is an uncommon autoimmune skin disease. The most common form in dogs is pemphigus foliaceus, which manifests as erosions and crusting of the skin and mucocutaneous junctions. Pemphigus vulgaris is more rare and manifests as blister-like lesions in the mouth and at mucocutaneous junctions. Bullous pemphigoid is most commonly seen in Dobermanns and Collies and appears as a scald-like lesion of the groin.[80]
- Sebaceous adenitis is an uncommon autoimmune skin disease. Most commonly found in Akitas and Standard Poodles.[81]
- Dermal fragility syndrome, also known as Ehlers-Danlos-like syndrome, is a rare condition in dogs characterized by increased skin elasticity and poor wound healing. There appears to be a genetic basis for the disease.[82]
- Discoid lupus erythematosus is an uncommon autoimmune disease of the skin in dogs. It does not progress to systemic lupus erythematosus in dogs. The most common initial symptom is scaling and loss of pigment on the nose.[33]
- Puppy strangles or juvenile cellulitis is a disease of unknown etiology that affects young puppies.

Cancers

- Canine transmissible venereal tumor is a tumor of the external genitalia (penis, vulva). It is spread by sexual contact and is more common in hot and humid climates.[6]
- Hemangiosarcoma is an aggressive tumor that msot often affects the heart, the spleen, the skin and subcutaneous tissues, and the liver.[83]
- Osteosarcoma is an aggressive bone tumor that commonly spreads to the lungs. It is more common in large and giant breed dogs.[83]
- Histiocytoma is a benign skin tumor that is more frequent in young dogs (<4 years), and often regresses without treatment.[83]
- Malignant histiocytosis (histiocytic sarcoma) is an aggressive cancer found primarily in certain breeds including the Bernese Mountain Dog, rottweiler, golden retriever and flat coated retriever. It is characterized by infiltration of the joints, lungs, spleen, lymph nodes, and other organs by malignanthistiocytes.[6]
- A mast cell tumor (mastocytoma) is a type of tumor normally found in the skin of dogs. It can also invade the subcutis and spread to the liver, spleen, or bone marrow.[84]
- Lymphoma (lymphosarcoma) is a malignant cancer that is classified by location, cell type, and histological grade. The most common form in dogs is multicentric, involving the lymph nodes.[83]
- Fibrosarcoma is a malignant tumor that most commonly occurs in the mouth in dogs, and less commonly in the skin, subcutis, and bones.[6]
- Squamous cell carcinoma* is a malignant tumor in dogs that most commonly occurs in the oral cavity, including the tongue, tonsils, and gingiva. Squamous cell carcinoma accounts for 5 percent of skin tumors in dogs, and are the most common tumor of the toe. Dogs with unpigmented skin on the nose may develop this cancer from long-term sun exposure.[83]
- Perianal gland tumor (also called hepatoid tumor) is a type of tumor found near the anus in dogs that arises from specialized glandular tissue found in the perineum. They are most common in intact (not neutered) male dogs.[83]
- Anal sac adenocarcinoma is an uncommon and aggressive malignant tumor found in dogs that arises from the tissue of anal sac.[83]
- Melanomas* account for four to six percent of skin tumors in dogs and are usually benign. They are the second most common tumor of the toe and are malignant in this location. Malignant melanoma is also a common oral tumor in dogs. Malignant tumors most commonly spread to the lymph nodes and lungs.[83]
- Leukemias* are progressive proliferation of cancerous white blood cells within the bone marrow, resulting in destruction of the bone marrow and pancytopenia in many cases. Types of leukemia in dogs include acute lymphoblastic leukemia, acute myelocytic leukemia, acute monocytic leukemia, acute myelomonocytic leukemia, acute megakaryocytic leukemia, chronic lymphocytic leukemia, chronic myelogenous leukemia, chronic basophilic leukemia, and chronic eosinophilic leukemia (or hypereosinophilic syndrome).[83]
- Plasmacytomas* are common skin tumors in dogs that derive from B lymphocytes. Most are benign. Tumors of B lymphocyte origin that affect the bone marrow and are diffuse throughout the body are malignant and are called multiple myeloma*.[83]
- Prostate cancer* is rare in dogs and occurs in both intact and neutered animals. It is malignant. The most common type is adenocarcinoma. Signs include blood in the urine and straining to urinate or defecate. It most commonly spreads to bone and the lungs.[83]
- Mammary tumors in dogs are potentially benign or malignant. They occur most commonly in non-spayed females or female that were spayed later in life.[83]
- Insulinomas* in dogs are insulin secreting tumors of the pancreas. The most common sign is hypoglycemia. They commonly metastasize to the liver.[83]
- Oral cancer* includes tumors of the tongue, tonsils, gingiva, and palate. The most common types are squamous cell carcinomas, malignant melanomas, and fibrosarcomas.[83]

- Ocular tumors* in dogs are found in the eyelid, conjunctiva, third eyelid, cornea, sclera, iris, ciliary body, retina, choroid, optic nerve, and orbit. The most common types are Meibomian gland adenoma (eyelid), papilloma (eyelid), melanoma (eyelid, conjunctiva, sclera, iris, ciliary body, choroid), squamous cell carcinoma (conjunctiva), adenoma (ciliary body), adenocarcinoma (ciliary body), lymphoma (retina, choroid, ciliary body), medulloepithelioma (retina, choroid), ganglioglioma (retina, choroid), osteosarcoma (orbit), mast cell tumor (orbit), and optic nerve sheath meningioma.[83]
- Nasal cancer makes up one to two percent of all types of tumors in dogs. Adenocarcinoma is the most common type, followed by sarcomas such as fiborsarcoma and chondrosarcoma. Signs include sneezing and bloody nasal discharge.[83]
- Thyroid cancer* is rare and usually nonproductive in dogs (unlike in cats, in which it causes hyperthyroidism). One-third of thyroid tumors are small benign adenomas; the rest are malignant carcinomas, usually large and invasive.[83]
- Gastrointestinal cancer* is uncommon in dogs. The most common type is lymphoma. Nonlymphomatous esophageal cancer is especially rare, the most common types being squamous cell carcinoma, adenocarcinoma, leiomyosarcoma, and osteogenic sarcoma associated with the parasite *Spirocerca lupi*. Nonlymphomatous stomach cancer is usually an adenocarcinoma, and nonlymphomatous intestinal cancer is usually polyps, adenomas, adenocarcinomas, leiomyosarcomas, and leiomyomas.[83]
- Kidney cancer* is uncommon in dogs. The most common type is renal cell carcinoma.[83]
- Lung cancer* is usually the result of metastasis in dogs. Primary tumors are rare. The most common type is adenocarcinoma.[83]
- Heart tumors* are rare in dogs. Types include hemangiosarcoma, fibrosarcoma, and fibroma.[83]
- Testicular tumors* are the most common tumor of the canine male reproductive tract. Tumor types include Sertoli cell tumor, seminoma, and interstitial cell tumor. None commonly metastasize.[83]
- Ovarian cancer* is uncommon in dogs, with the most common type being the granulosa cell tumor. This type of tumor can metastasize and can cause cystic endometrial hyperplasia.[83]
- Uterine cancer* is very rare in dogs. The most common type is benign leiomyoma.[83]
- Bladder cancer* is usually malignant in dogs. The most common type is transitional cell carcinoma.[83]
- Liver cancer* is usually metastatic in dogs. Primary tumors are and include benign hepatocellular adenoma (hepatoma) and malignant hepatic carcinoids.[83]
- Brain tumors* can be either metastatic or primary in dogs. The incidence of primary tumors is 14.5 per 100,000 dogs at risk. Types include meningioma, astrocytoma, oligodendroglioma, and undifferentiated sarcoma.[83]
- Behavioral

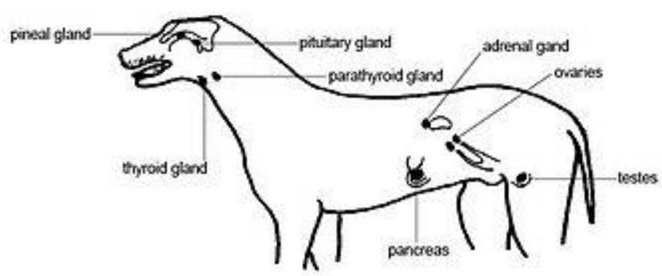
- Pica is an appetite for, or the behavior of eating, non-nutritive substances (e.g., sand, coal, soil, chalk, paper etc.). Pica can be dangerous to dogs, with a risk from eating dirt near roads that existed prior to the phaseout of tetraethyllead in gasoline or prior to the cessation of the use of contaminated oil (either used, or containing toxic PCBs) to settle dust. In addition to poisoning, there is a risk of gastro-intestinal obstruction or tearing in the stomach or blockage of the esophagus.
- Pica in dogs may be a sign of Immune-mediated hemolytic anemia, especially when it involves eating substances such as tile grout, concrete dust, and sand. Dogs exhibiting this form of pica should be tested for anemia with a Complete blood count including Hematocrit levels, or Packed cell volume.[46][47]

- Coprophagia is the ingestion by a dog of feces, either its own or those of another dog or animal. It can be caused by medical conditions such as exocrine pancreatic insufficiency, overfeeding, or malabsorption. It can also be a behavioral problem characterized by attention-seeking, reinforcement, or as a learned behavior. Numerous health problems can arise from this activity, including internal parasites or infection with *canine parvovirus* or toxoplasmosis. Treatment includes behavioral modification therapy or altering the feces to affect its taste.[85]

Environmental

- Sensitivity to anaesthesia can occur in any breed, but sighthounds have been the breeds most documented to have anesthetic concerns. Sighthounds are known to have prolonged recovery times from ultra short-acting thiobarbiturates such as thiopental.[86]
- Heat stroke can occur in dogs, especially in flat-faced breeds such as the Bulldog or in giant breeds. Breed, lack of water, exercise, and high ambient temperature predispose dogs to heat stroke. Signs include vomiting, diarrhea, collapse, difficulty breathing, and body temperature approaching 42 °C to 43 °C. Treatment includes cooling the dogs with wet towels and fans, intravenous fluid therapy, and other supportive care.[87] If a dog's temperature begin to drop to around 40 °C, stop the cooling process. Once a dog’s body begins to cool, it can drop quickly and getting them too cool can create different problems. Allow the dog only a couple of laps of water until their temperature begins to drop to a more normal level. Do not allow a dog to gulp large quantities of water. If a dog is panting excessively and then drinks a lot of water, he will swallow large amounts of air with the water and this can cause an equally life-threatening case of bloat in their stomach.[88]
- Foxtails and sandburs can penetrate the lining of the mouth or skin and migrate, causing abscesses and draining tracts.[89]

Endocrine diseases



Shown here are the pituitary gland: (**Acromegaly**, a form of **Cushing's disease**, a form of **Diabetes Insipidus**, **atypical Addison's diesase**), the ovary for females: (**Secondary Diabetes**, **Transient Diabetes**), the adrenal gland: (a form of **Cushing's disease**, **typical Addison's disease**), the thyroid gland: (**Hypothyroidism**), and the pancreas: (**Diabetes Mellitus**).

- Diabetes mellitus in dogs is type 1, or insulin dependent diabetes: a lack of insulin production due to destruction of pancreatic beta cells.[90][91][92] Current research indicates no evidence of type 2 diabetes in dogs.[93] Among the causes of diabetes mellitus in dogs are autoimmune disease or severe pancreatitis.[94] Forms of diabetes which may not be permanent, depending on the amount of damage to the beta cells of the endocrine pancreas,[95] are transient and secondary diabetes. Some causes of transient or secondary diabetes are Cushing's syndrome, glucocorticoid, progestin or other steroid use, and the hormones of pregnancy or heat. In these cases, correcting the primary medical issue may mean a return to non-diabetic status.[94][96][97] Common signs include weight loss, increased drinking and urination, and cataracts. Treatment involves twice daily insulin doses (replacement therapy)[98] and use of a diet high in fiber and complex carbohydrates.[99] Oral diabetes medications are not able to be used for dogs because none are capable of repairing or surmounting the permanent damage to the beta cells of the pancreas.[91][100][101][102]

- Thyroid diseases, including:
    - Hyperthyroidism* is rare in dogs. The most common cause is thyroid carcinoma, a malignant tumor. Signs include weight loss, increased appetite, and enlargement of the thyroid gland.[103]

  - Hypothyroidism is the most common endocrine disease in dogs. It can be caused by autoimmune destruction (lymphocytic thyroiditis) or idiopathic atrophy of the thyroid gland.[104] These two causes are responsible for over 95% of the hypothyroidism cases in dogs.[105] Signs include decreased appetite, weight gain, hair loss, dry skin/coat, skin that is cold to the touch, recurring skin infections, and lethargy. The dog may also seek out warm places to lie. The symptoms of hypothyroidism are shared with many other medical conditions; it may not be the first thought when a diagnosis is made.[106] Symptoms may not appear until 75% or more of the gland is non-functional. In less than 10% of hypothyroidism cases, the problem is not with the thyroid gland itself, but with the pituitary gland in the brain. The pituitary gland produces a thyroid stimulating hormone (TSH);[107] without this hormone to signal the thyroid gland to produce its thyroid hormone, the thyroid gland remains inactive.[105] Treatment is with oral thyroid hormone supplementation.[108][109] Lack of enough iodine in the diet can produce a form of hypothyroidism; without the proper amount of it, the thyroid gland fails to produce enough thyroid hormone.[105]Myxedema coma is a rare but serious aspect of the disease that is a medical emergency.[110]
- Addison's disease, also known as hypoadrenocorticism,[111] is a reduction of production of glucocorticoids and mineralocorticoids by the adrenal glands. There is more familiarity with the glucocortcoids, such as cortisol; mineralocorticoids control the amount of potassium, salt and water in the body.[112][113][114] It is most commonly caused by destruction of adrenal tissue, probably by autoimmune disease. Signs include increased drinking and urination, vomiting, diarrhea, collapse, shivering and weight loss; at times neither the causes nor symptoms are especially specific.[115][116] Because of this it is sometimes referred to as "the Great Mimic" or "the Great Imitator".[113][117] It is possible not to see any symptoms of the disease until the adrenal cortex is 90% dysfunctional.[118] Addison's can occur when regular steroid use is abruptly discontinued; during their use, the system the adrenal gland does not function at 100%. The system senses sufficient levels of these hormones in the body and does not signal for their production. Tapering the medication off gradually allows them to return to full production after discontinuation.[116][118] About 35% of canine Addison's patients are not diagnosed until they experience an Addisonian crisis, which outwardly appears to be a "classic" shock and is a medical emergency.[110][118]Hyperkalemia[112] can develop and cause severe bradycardia. Only typical Addison's patients have the risk of Addisonian crisis due to the lack of mineralocorticoids.[116] Treatment is with supplementation of mineralocorticoids in daily pills or a monthly injection. The atypical form and the form caused by abrupt withdrawal of steroids do not need mineralocorticoids.[116] Glucocorticoids are usually supplemented with oral prednisone.[119][120]

- Cushing's syndrome, also known as hyperadrenocorticism, is a condition characterized by an increase in glucocorticoids secreted by the adrenal glands. About 85 percent of cases are caused by a tumor in the pituitary gland, while 15 percent are caused by an adrenal tumor. The pituitary gland produces a hormone that signals the adrenal gland to produce cortisol; a tumor can cause it to produce the adrenal-stimulating hormone even when it is not needed.[121][122] Signs include increased appetite, increased drinking and urination, a pot-bellied appearance, muscle weakness, and lethargy.[121] Cushing's can be caused by overuse of steroid medications; in some cases, stopping the medication is enough to solve the problem.[121] Diagnosis can be difficult as there are no tests with both high sensitivity and specificity.[123] Treatments inclulde mitotane, trilostane,[124][125]ketoconazole, or selegiline.[126][127] Surgery is used in some cases of adrenal tumors.[128]
- Diabetes insipidus* in dogs and cats can be central, caused by a lack of antidiuretic hormone (ADH), or nephrogenic, caused by a lack of response of the kidneys to ADH. Neither form is common. Central diabetes insipidus (CDI) is usually idiopathic, but can also be caused by head trauma[129] or tumors of the brain. Nephrogenic diabetes insipidus (NDI) can be primary (hereditary) or secondary (caused by a variety of metabolic[130] and renal diseases, including Cushing's syndrome and pyometra). Because the disease is characterized by an inability to concentrate urine, the most common sign is increased drinking

and urinating.[131][132] Treatment of CDI is to use desmopressin, a synthetic analog of ADH. Treatment of NDI is to treat the underlying cause, if any.[133]

- Acromegaly (also known as hypersomatotropism) is a hormonal condition resulting from over-secretion of the growth hormone somatotropin[134] from the pituitary gland.[135] The hormone is responsible for growth from birth to adulthood. Normally in adulthood, the growth plates of the bones close and the secretion of the hormone slows considerably. Because the bone plates close when entering maturity, the continued growth of acromegaly is not of normal proportions.[136] Most canine sufferers of the disease are unspayed females but the condition can come about with use of medications containing progesterone.[136][137][138][139][140] Acromegaly patients often also have diabetes mellitus.[141][142] There is a transient form of acromegaly which can affect females at the diestrus portion of the reproductive cycle.[130] This condition is brought about by the mammary glands[143] excreting excess growth hormone, which is triggered by progesterone from the ovaries. As with non-transient acromegaly, spaying is necessary.[141] The symptoms can include overgrowth or enlargement of gums with wide spaces between teeth,[136] increased drinking, increased urination, thickening of the skin and skin folds, enlargement of the tongue and excessive panting.[144] Acromegaly is also possible from a somatotroph adenoma.[144] The hormone somatostatin can also be useful in treatment.[145] Since hypothyroidism is connected with the release of excess growth hormone, hypothyroidism can be mistaken for acromegaly.[146]

Gastrointestinal diseases

- Megaesophagus is a disease of the esophagus characterized by low motility and dilation. Most cases in adult dogs are idiopathic. It is the most common cause of regurgitation in dogs. Other causes of megaesophagus include myasthenia gravis, lead poisoning, and Addison's disease.[147]
- Bloat*, also known as torsion or gastric dilatation volvulus, is a serious condition in which the stomach swells with air (gastric dilatation), sometimes twisting on itself (volvulus). Deep-chested breeds are at a higher risk of bloating. Factors that predispose dogs to this condition are intestinal foreign bodies, intestinal cancer, intussusception, and other intestinal diseases. It has a poor prognosis.[148]
- Foreign body is an object foreign to the body that becomes lodged in the gastrointestinal tract (or other part of the dog). Dogs are susceptible to gastrointestinal obstruction due to their ability to swallow relatively large objects and pass them through the esophagus. Foreign bodies most commonly become lodged in the stomach because of the inability to pass through the pyloric sphincter, and in the jejunum.
- Anal fistulae*, known as perianal fistulae in dogs, are most common in German Shepherd Dogs. They are characterized by draining tracts in the skin around the anus. The cause is unknown. Surgical treatment is common, but recently use of cyclosporine in combination with ketoconazole has been shown to be effective.[149]
- Exocrine pancreatic insufficiency is the inability to properly digest food due to a lack of digestive enzymes made by the pancreas. This disease is found frequently in dogs.[6]
- Pancreatitis*, or inflammation of the pancreas, is common in dogs. It is most commonly seen in middle-aged and older overweight dogs. Miniature Schnauzers are predisposed. Contributing factors include diabetes, hyperlipidemia, obesity, and dietary indiscretion. Signs include vomiting, diarrhea, abdominal pain, lethargy, and anorexia.[150]
- Inflammatory bowel disease (IBD)* is a group of diseases in dogs that are idiopathic and characterized by the presence of inflammatory cell infiltrates in the stomach and/or intestinal walls. It is a common condition. Signs include vomiting, diarrhea, and weight loss. Treatment is with dietary modification and use of medications such as corticosteroids, metronidazole, sulfasalazine, and azathioprine.[151]

- Bilious vomiting syndrome is vomiting in response to bile-induced inflammation of the stomach. Bile salts interfere with the gastric mucosal barrier, allowing acid to irritate the stomach lining and cause gastritis.[152]
- Intussusception* is characterized by telescoping of one part of the gastrointestinal tract into another part, forming an obstruction. It is most common in dogs six to eight months old. Surgery is necessary for treatment.[153]
- Lymphangiectasia is an intestinal disease of dogs characterized by chronic diarrhea and loss of proteins such as serum albumin and globulin. It is considered to be a chronic form of protein-losing enteropathy. Breeds commonly affected include the Soft-Coated Wheaten Terrier, Norwegian Lundehund, Basenji, and Yorkshire Terrier.[6]
- Hemorrhagic gastroenteritis is a disease of dogs characterized by sudden vomiting and bloody diarrhea. The symptoms are usually severe and can be fatal if not treated. It is most common in young adult dogs of any breed, but especially small dogs such as the Toy Poodle and Miniature Schnauzer.[6]

Urinary and reproductive systems

- Kidney diseases
    - Fanconi syndrome is a type of renal tubule disease found in Basenjis. Findings include the inability to concentrate urine, and the presence of glucose, protein, and amino acids in the urine.[6]
    - Renal failure (kidney failure) * is common in dogs and may be found in acute or chronic forms. It is defined by a loss of function of about 75 percent of the filtration system of the kidney and characterized by azotemia and low specific gravity of the urine.[154] Acute renal failure can be caused by loss of blood supply, hypercalcemia, or toxins such as ethylene glycol (antifreeze) or aminoglycosideantibiotics[155] (see: *ethylene glycol poisoning*). Chronic renal failure can be congenital and/or inherited or caused by cancer, infection, hypertension, glomerulonephritis, amyloidosis, progressive interstitial fibrosis, or any of the causes of acute renal failure.[156]
    - Glomerulonephritis* is the presence of immune complexes in the glomerulus, resulting in leakage of protein into the urine. It can be caused by cancer, heartworm disease, pyometra, rickettsial infection, or systemic lupus erythematosus.[157] It can result in chronic kidney failure, hypoalbuminemia, which can cause ascites and peripheral edema, and nephrotic syndrome, which can cause hypertension or hypercoagulability.[158]
    - Familial renal disease is an uncommon cause of renal failure (kidney failure) in young dogs. Most causes are breed-related (familial) and some are inherited.
    - Samoyed hereditary glomerulopathy (SHG) is an hereditary noninflammatory disease, of the renalglomeruli occurring in the Samoyed breed of dog. The disease has been shown to be a model for hereditary nephritis (HN) in humans[159]
- Urinary bladder diseases
    - Bladder stones or uroliths are common in dogs. The stones form in the urinary bladder in varying size and numbers secondary to infection, dietary influences, and genetics. Types of stones include struvite, calcium oxalate, urate, cystine, calcium phosphate, and silicate. Struvite and calcium oxalate stones are by far the most common.[6]
    - Urinary tract infection*, specifically cystitis or bladder infection, is common in dogs and usually caused by bacteria. Signs include blood in the urine (hematuria), difficulty urinating (dysuria), and frequent urination (polyuria).[160] The most common types of bacteria cultured from the urine of dogs with cystitis are *E. coli*, *Staphylococcus* spp., *Proteus mirabilis*, *Streptococcus* spp., *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, and *Enterobacter* spp.[161]
    - Urinary incontinence* is leakage of urine, usually due to incompetence of the urethral sphincter in adult dogs and ectopic ureter (a congenital condition in which the ureter enters the urinary tract posterior to the urethral sphincter) in puppies. In adult dogs it is most commonly seen in

large spayed females. The lack of estrogens in spayed dogs has been linked to development of incontinence. Replacement of estrogens, phenylpropanolamine, and surgery have all been used for treatment.[162]

- Reproductive diseases
  - Prostate disease* in dogs includes benign prostatic hyperplasia (BPH), prostatitis (infection of the prostate), cancer, and cysts and abscesses. BPH is the most common and is found in older intact (not neutered) dogs. Signs include blood in the urine and straining to urinate and defecate. Castration is the treatment of choice.[163] Prostatis can be associated with BPH. Bacteria causing prostatitis include *E. coli*, *Staphylococcus* spp., *Streptococcus* spp., and *Mycoplasma* spp.[164]
  - Cryptorchidism is when one the testicles is retained in the abdomen or inguinal canal past a normal stage of development. It is a common occurrence in dogs and is thought to be a sex-limitedautosomal recessive trait.[6]
  - False pregnancy*, or pseudocyesis, is a common condition in female intact dogs. Signs include swelling of the mammary glands, lactation, not eating, and "mothering" small objects.[165]
  - Pyometra is an infection of the uterus. It is a common and potentially fatal condition in dogs. The main risk period for a female is for eight weeks after her peak standing heat (or estrus cycle) has ended.[6]
- Umbilical hernia* is a failure of the umbilical ring of the abdominal wall to close. They are very common and can be caused by genetics or by traction on the umbilical cord or by the cord being cut too close to the body. They are corrected by surgery.[166]
- Inguinal hernia* is a protrusion of abdominal contents through the inguinal canal. They are corrected through surgery.

Poisons and overdoses

- Acetaminophen (paracetamol, Tylenol) can cause liver damage in dogs. The toxic dose is 150 mg/kg.[167]
- Ibuprofen (Advil)* can cause gastrointestinal irritation, stomach ulcers, and kidney damage in dogs.[168]
- Naproxen (Aleve)* has a long half-life in dogs and can cause gastrointestinal irritation, anemia, melena (digested blood in feces), and vomiting.[168]
- Antifreeze* is very dangerous to dogs and causes central nervous system depression and acute renal failure. Treatment needs to be within eight hours of ingestion to be successful.[167] See Ethylene glycol poisoning.
- Mouse and rat poison* ingestion is common in dogs. Most rodenticides in the United States are anticoagulant by depleting Vitamin K. This type is the most frequent cause of poisoning in pets. Third generation products contain brodifacoum or bromadiolone and are toxic after a single ingestion. Signs include spontaneous and excessive bleeding internally and externally. Treatment is with Vitamin K supplementation. Other rodenticides may contain cholecalciferol which causes hypercalcemia and leads to heart and kidney problems. Newer rodenticides may contain bromethalin which causes central nervous system signs such as seizures, muscle tremors, and depression.[169]
- Insecticides* used in dogs for fleas and ticks commonly contain either organophosphates or carbamates. they can be absorbed through the skin, conjunctiva, gastrointestinal tract, and lungs. Organophosphates inhibit acetylcholinesterase irreversibly and carbamates inhibit cholinesterase reversibly. Toxicity occurs through overdosage with an appropriate product or use of an agricultural product. Signs for both include hypersalivation, vomiting, lethargy, tremors, difficulty walking, weakness, and death.[167]
- Chocolate is a common cause of poisoning in dogs. The toxic principles in chocolate are theobromine and caffeine. Baker's chocolate is the most dangerous form since it contains higher concentrations of these drugs, followed by semi-sweet, dark, and then milk chocolate. Signs include vomiting, diarrhea, tremors, difficulty walking, seizures, and heart problems.[170]

- Lead poisoning* is uncommon in dogs. Exposure to lead is from eating paint chips from lead-based paint (found in houses painted prior to 1950), and eating lead objects such as shot, fishing sinkers, or counterweights. Signs of poisoning include vomiting, diarrhea, blindness, seizures, and tremors.[167]
- Raisins and grapes are potential causes of kidney failure in dogs.[171]
- Garlic & Onions* are toxic to dogs. Onions, Garlic, Chives - can cause the destruction of red blood cells known as Heinz body anemia, a form of hemolytic anemia. No clear quantity has been established as to the onset of the anemia. But for garlic, if your dog consumes the equivalent of 1 teaspoon of garlic for every 10 pounds of their weight (1 teaspoon for a 10 pound dog) it can destroy red blood cells. Poisonous reaction can result from raw, cooked or dried onions, garlic, chives, including those included in powdered or dehydrated forms. Avoid all foods that contain onions or onion variants (such as spaghetti sauce).

Miscellaneous

- Vertigo*, better known as vestibular disease* in dogs, is an uncommon condition in older dogs. Most cases are idiopathic, but it can also be caused by otitis interna, or inner ear infection, tumors, and encephalitis. Signs include nystagmus, head tilt, circling, vomiting, and falling to one side. Idiopathic vestibular disease will usually resolve in a few days to a few weeks.[172]
- Molera (hole in skull), better known as an open fontanelle, may be a sign of hydrocephalus, but is also a normal finding in toy breeds such as Chihuahua.[173]
- Anal gland problems are a very common issue with dogs. Disease of the anal glands or anal sacs may include impaction, infection, or abscessation. The dog will periodically discharge a fishy-smelling substance from its anus when they get too full. These glands are normally expressed when the dog defecates.
- Shar Pei fever is a condition seen in Shar Peis characterized by recurring fever and swelling of the hocks. Shar Pei fever can result in renal and liver failure through accumulation of amyloid in those organs (amyloidosis).[6]
- Liver failure* is common in dogs. Signs include vomiting, loss of appetite, weight loss, and jaundice. Causes include bacterial or viral infection, toxic insult, cancer, copper storage diseases, or it may be idiopathic.[174]
- Dental disease is very common in dogs. Calculus is the most obvious sign of dental disease, but gingivitis progressing to periodontitis is what results in tooth loss. Treatment involves scaling and polishing of the teeth under general anesthesia and treatment of any periodontal disease. Prevention is very important and can be accomplished through the use of special diets or treats, brushing, and plaque prevention gels.[175]
- Portosystemic shunt, also known as a liver shunt, is a bypass of the liver by the body's circulatory system. It can be either a congenital or acquired condition.
- Perineal hernia is a condition seen in dogs characterized by herniation of abdominal contents through the pelvic diaphragm and causing swelling on one side of the anus.
- Primary ciliary dyskinesia* is a disorder causing dysfunction of cilia. In dogs this manifests as sperm immotility and respiratory disease. Signs include nasal discharge, recurring pneumonia, and infertility. Symptoms develop soon after birth.[176]
- Cleft lip and palate is occasionally seen in dogs. Difficulty with nursing is the most common problem associated with clefts, but aspiration pneumonia may be seen with a cleft palate.[6]
- Congenital diaphragmatic hernia* is uncommon in dogs. Most diaphragmatic hernias are caused by trauma. Congenital diaphragmatic hernias are usually communications between the peritoneum and pericardium. They are often incidental findings.[177]
- Gingival hyperplasia is seen in brachycephalic breeds, especially Boxers. It is a benign condition, although food and hair impaction is common.[178]

- Salmon poisoning disease is a fatal disease of dogs caused by infection with a type of rickettsia, either *Neorickettsia helminthoeca* or *Neorickettsia elokominica*. It results from eating raw salmon and is found in the Pacific Northwest.[6]
- Vaccine reactions can be considered any type of adverse event stemming from vaccination, including granuloma formation, but most commonly the term vaccine reaction is used to describe a type I hypersensitivity reaction. The most common signs are facial swelling and hives, but more rarely very serious signs such as hypotension and collapse may occur.[179]
- Systemic lupus erythematosus (SLE)* is a disease of the immune system characterized by the presence of antibodies to nucleic acid and/or antibodies to red blood cells, platelets, lymphocytes, clotting factors, and thyroglobulin. The disease can result in deposition of immune complexes or autoimmune disease. Immune complex deposition can cause vasculitis, meningitis, neuritis, and joint and skin disease. Autoimmune disease may result in hemolytic anemia or thrombocytopenia, which are the most common manifestations of SLE in dogs.[180]
- Myasthenia gravis* results from the presence of antibodies to the acetylcholine receptor. Signs include megaesophagus and muscle weakness.[181]
- Tetanus* is a disease caused by the bacteria *Clostridium tetani* following wound contamination. Dogs are not very susceptible to tetanus. Signs include difficulty opening the mouth and eating, contraction of the facial muscles, and rigid extension of the limbs. Dogs may also get localized tetanus, signs of which include stiffness of a limb spreading to the rest of the body.[182]
- Polydactyly* is generally preaxial (on the dewclaw side) in dogs. Most cases are breed related, with the Great Pyrenees being the most well known example.[183]
- Tracheal collapse is a condition characterized by incomplete formation or weakening of the cartilagenous rings of the trachea. It is most common in small and toy breeds. Signs include a cough (often called a "goose honk cough" due to its sound), especially when excited.[6]
- Brachycephalic syndrome is a condition seen in brachycephalic (short-nosed) dogs, characterized by the presence of stenotic nares, elongated soft palate, narrow trachea, collapsed larynx, and everted laryngeal saccules. Signs include difficult and noisy breathing. Surgical options are available.[184]

https://en.wikipedia.org/wiki/List_of_dog_diseases

13. Describe the 12 Cranial nerves and their functions.

The Cranial Nerves

Nerve	Function
Olfactory nerves	Transmit smell
Optic nerves	Necessary for vision; carry the sensory nerves for certain eye reflexes
Oculomotor nerves	Carry motor neurons that control most of the muscles of the eye
Trochlear nerves	Carry motor neurons that control other muscles of the eye

Trigeminal nerves	Include 3 main branches: the motor nerve to the muscles of the jaw, sensory nerves to the mouth and nasal cavity, and sensory nerves that carry pain sensations from the cornea (the sensitive outermost part of the eyeball)
Abducent nerves	Carry motor neurons that control other muscles of the eye
Facial nerves	Control the muscles responsible for facial expression (ears, eyelids, nose, and mouth)
Vestibulocochlear nerves	These nerves are divided into 2 parts: the cochlear nerve, which responds to sound; and the vestibular nerve, which functions to maintain posture and balance
Glossopharyngeal nerves	Provide sensory and motor control of the throat and vocal chords
Vagus nerves	Provide sensory and motor control for the major internal organs, including the heart and the digestive tract
Spinal accessory nerves	Carry sensory and motor information for the muscles of the head and upper neck
Hypoglossal nerves	The motor nerves to the tongue

Evaluation of the nervous system begins with an accurate history and general physical examination, followed by a neurologic examination. There are a number of specific physical tests that can be carried out to evaluate the functioning of the various components of the nervous system. These include tests of various reflexes, muscle function and control, and posture and gait.

Laboratory tests are often needed to diagnose the specific problem. Common laboratory tests include blood tests, urinalysis, analysis of the cerebrospinal fluid, x-rays, computed tomography (CT) scans, magnetic resonance imaging (MRI), and evaluation of the electrical activity of the brain, peripheral nerves, and muscles.

The Neurologic Examination

A neurologic examination evaluates 1) the cranial nerves, 2) the gait, or walk, 3) the neck and front legs, and 4) the torso, hind legs, anus, and tail. Your pet's reflexes will also be tested to determine, if possible, the location of the injury in the brain, spinal cord, or nerves in the peripheral nervous system.

Evaluation of the Cranial Nerves

The 12 pairs of cranial nerves extend from specific segments of the brain stem to the left and right sides of the head (see Brain, Spinal Cord, and Nerve Disorders of Dogs: The Cranial Nerves). They include the nerves that transmit smell, those responsible for vision and the movement of the eyes, those that control facial movements, those responsible for hearing and balance, and those responsible for chewing, swallowing, barking, and movement of the tongue. Testing the reflexes of these nerves can help identify the location of the damage. Your veterinarian will perform specific tests designed to pinpoint any signs of dysfunction in these nerves.

An evaluation of the cranial nerves tests mental activity, head posture and coordination, and reflexes on the head. Signs identified during this evaluation indicate an injury or disease of the brain. Signs of damage to the cerebrum and brain stem can include mental deterioration, constant pacing, seizures, depression or coma, or a head turn or circling in one direction. A head tilt, bobbing, tremors, or other unusual head movements may indicate damage to the cerebellum.

Evaluation of Gait (Walking)

Your veterinarian will evaluate the gait by watching your pet as it walks, runs, turns, steps to the side, and backs up. Signs of dysfunction include circling, weakness or complete paralysis of any limbs, falling, stumbling, rolling, or loss of coordination.

Evaluation of the Neck and Front Legs

Evaluation of the neck and front legs will include searching for evidence of pain and loss of muscle size or tone, which may indicate an injury to the upper spinal cord. Various types of tests are done to help detect minor spinal cord injuries.

Some examples of tests that are commonly used to evaluate the neck and front legs include the wheelbarrow test (in which the back legs are lifted slightly and the animal is evaluated while walking on its front legs), the righting test (in which the dog is placed on its side or upside down to see how well it can right itself), and the positioning test (in which a foot or limb is moved from its normal position in order to evaluate how quickly and accurately the dog resumes its normal stance). Spinal reflexes and muscle condition are also evaluated.

Evaluation of the Torso, Hind Legs, Anus, and Tail

The trunk, or torso, is evaluated for abnormal posture or position of the vertebrae, pain, loss of feeling or hypersensitivity to light touch or pinpricking, and loss of muscle mass. Some tests used to evaluate the nerves of the neck and front legs (*see* above) are also used to evaluate the torso and hind legs. Various reflexes can also be evaluated. Loss of muscle around the torso or hind legs can indicate damage to a nerve associated with that muscle.

Laboratory Tests and Imaging

Blood tests are often used to detect metabolic disorders, some of which can affect nervous system activity. Blood tests can also identify other conditions, including lead poisoning, certain infections, and myasthenia gravis, an autoimmune disease in which the connections between nerve and muscle are blocked and weakness results.

Analysis of cerebrospinal fluid (the fluid that surrounds the brain and spinal cord) is often useful for diagnosing a central nervous system disorder. Cerebrospinal fluid is collected from the base of the skull or from the lower back in a procedure called a **spinal tap**. An unusually high amount of protein in the cerebrospinal fluid may indicate encephalitis (inflammation of the brain), meningitis (inflammation of the covering of the brain), cancer, or a compressive injury of the spinal cord. Increased numbers of white blood cells in the cerebrospinal fluid indicate an inflammation or infection. Other disorders that can be identified by cerebrospinal fluid analysis include bacterial or fungal infections, internal bleeding, brain abscesses, and some types of tumors. Cerebrospinal fluid can also be tested for the presence of canine distemper virus, Rocky Mountain spotted fever, and some other infectious diseases.

Several different types of radiographic tests can be used to detect disorders of the nervous system. **Plain x-rays** of the skull and spine can detect fractures, infections, or bone cancer. However, in most infections or cancers of the brain and spinal cord, plain x-rays appear normal. In a procedure known as **my-elography**, a special dye that is visible on x-rays is injected into the cerebrospinal canal. This dye can highlight specific types of spinal problems, such as herniated ("slipped") disks and spinal cord tumors. **Computed tomography (CT)** and **magnetic resonance imaging (MRI) scans** can also help evaluate changes in bone structure, internal bleeding, abscesses, inflammation, and certain nervous system cancers.

Other tests may be used in some cases. An **electroencephalogram** records electrical activity in the brain. Results are abnormal in meningitis or encephalitis, head injuries, and brain tumors. An electroencephalogram can sometimes help determine the cause and severity of a seizure. An **electromyogram** records electrical activity in muscles and nerves. In this test, a nerve is stimulated electrically, and the speed of conduction along the neurons is calculated. This technique can detect nerve injury and myasthenia gravis. A **brain stem auditory evoked response (BAER)** records electrical activity in the pathway from the sound receptors in the ear to the brain stem and cerebrum. In cases of deafness caused by nerve damage, the BAER generates no response. Brain-stem disorders may also change the BAER.

http://www.merckvetmanual.com/pethealth/dog_disorders_and_diseases/brain_spinal_cord_and_nerve_disorders_of_dogs/the_neurologic_evaluation_of_dogs.html

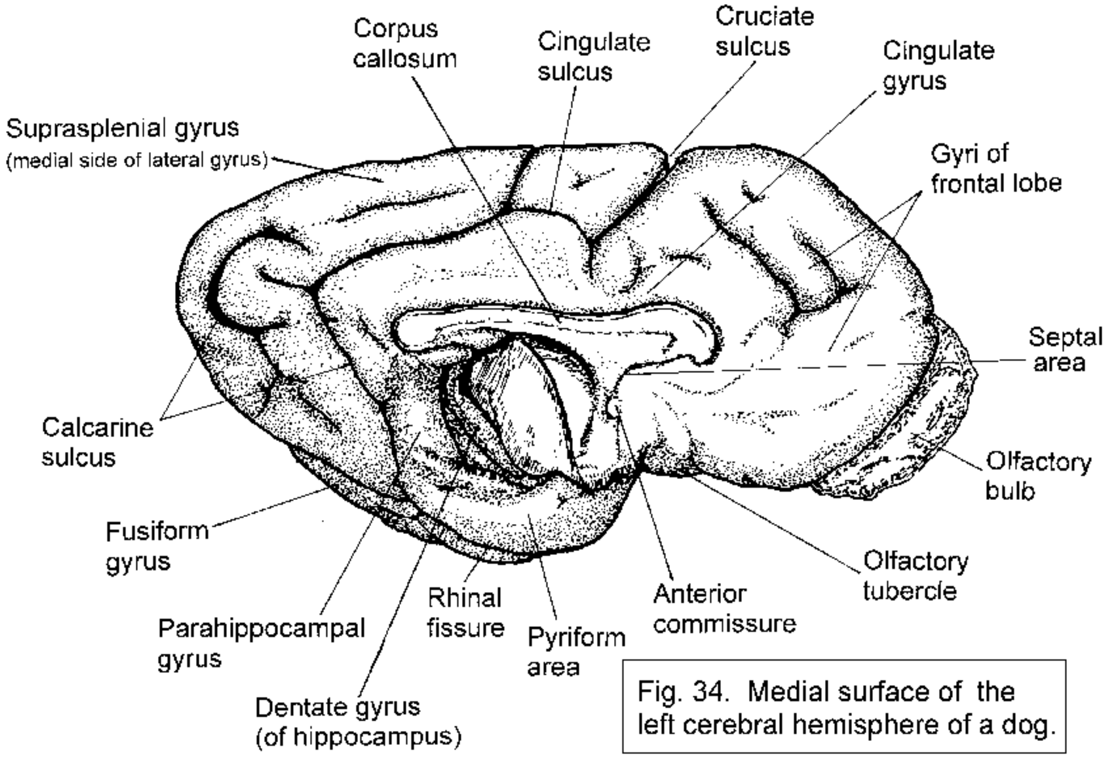


Fig. 34. Medial surface of the left cerebral hemisphere of a dog.

http://instruct.uwo.ca/anatomy/530/dogmedl.gif

14. What can you discover about the Vegus nerve?

Table 1. Summary of Central Connections, Components, Function, and Peripheral Distribution of the Vagus Nerve

Components	**Function**	**Central connection**	**Cell bodies**	**Peripheral distribution**
Branchial motor (efferent special visceral)	Swallowing, phonation	Nucleus ambiguus	Nucleus ambiguus	Pharyngeal branches, superior and inferior laryngeal nerves
Visceral motor (efferent general visceral)	Involuntary muscle and gland control	Dorsal motor nucleus X	Dorsal motor nucleus X	Cardiac, pulmonary, esophageal, gastric, celiac plexuses, and muscles, and glands of the digestive tract
Visceral sensory (afferent general visceral)	Visceral sensibility	Nucleus tractus solitarius	Inferior ganglion X	Cervical, thoracic, abdominal fibers, and carotid and aortic bodies
Visceral sensory (afferent special visceral)	Taste	Nucleus tractus solitarius	Inferior ganglion X	Branches to epiglottis and taste buds
General sensory (afferent general	Cutaneous sensibility	Nucleus spinal tract V	Superior ganglion X	Auricular branch to external ear, meatus, and tympanic membrane

somatic)

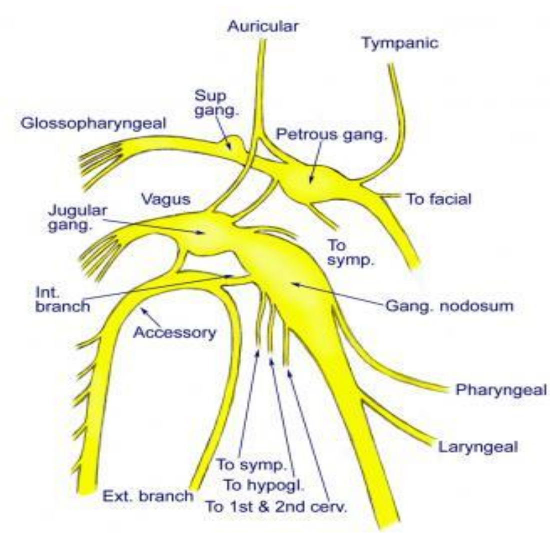
Table 2. The Pathway According to the Type of Nerve Fibers of the Vagus Nerve

Type	**Pathway**
Branchial motor (efferent special visceral)	Corticobulbar (bilateral) fibers descend through the internal capsule to synapse in the nucleus ambiguus. The axons of the lower motor neurons come out as 8-10 rootlets between the olive and pyramid, exiting the skull through the jugular foramen. They then divide into 3 main branches: the pharyngeal, superior, and recurrent laryngeal nerves.
Visceral motor (efferent general visceral)	Fibers from the dorsal motor nucleus X pass through the spinal trigeminal nucleus and tract, emerging from the medulla oblongata lateral surface to join the rest of the vagus.
Visceral sensory (afferent general and special visceral)	Nerve cells are located in the inferior (nodose) ganglion of the vagus. They receive input from the chemoreceptors of the aortic body and other visceral structures. Axons then descend to the tractus solitarius after entering the medulla.
General sensory (afferent general somatic)	The Xth cranial nerve carries visceral sensory fibers of the recurrent and the internal laryngeal nerves that supply sensations to the larynx. The auricular branch supplies sensations to the posterior parts of the pinna, external auditory canal, and tympanic membrane. Nerve cells are located in the superior (jugular) ganglion of the vagus.

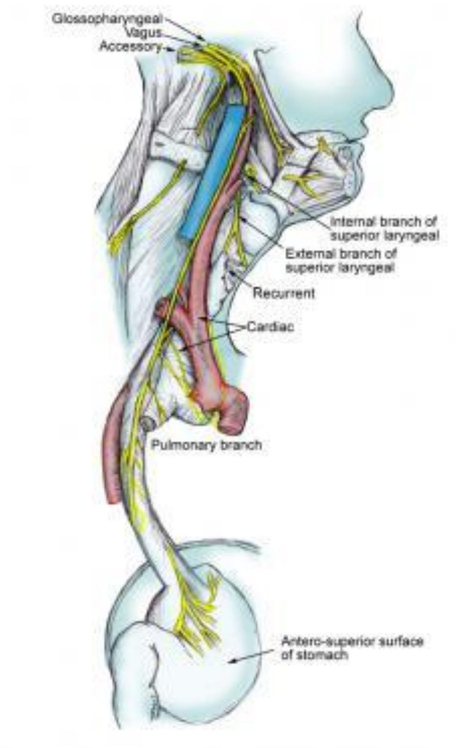
The vagus nerve is the longest cranial nerve. It contains motor and sensory fibers and, because it passes through the neck and thorax to the abdomen, has the widest distribution in the body. It contains somatic and visceral afferent fibers, as well as general and special visceral efferent fibers. (See Table 1, below.)

Exit from the brain

The vagus nerve exits from the medulla oblongata in the groove between the olive and the inferior cerebellar peduncle. It leaves the skull through the middle compartment of the jugular foramen, where it has upper and lower ganglionic swellings, which are the sensory ganglia of the nerve. The superior ganglion (jugular) is less than 0.5 cm in diameter, while the inferior (nodose) ganglion is larger (2.5 cm) and lies 1 cm distal to the superior ganglion (see the image below). The vagus nerve is joined by the cranial root of the accessory nerve (cranial nerve XI), just below the inferior ganglion. (See the images below.)[1, 2, 3, 4]



Connections of the vagus to the glossopharyngeal and accessory nerves.



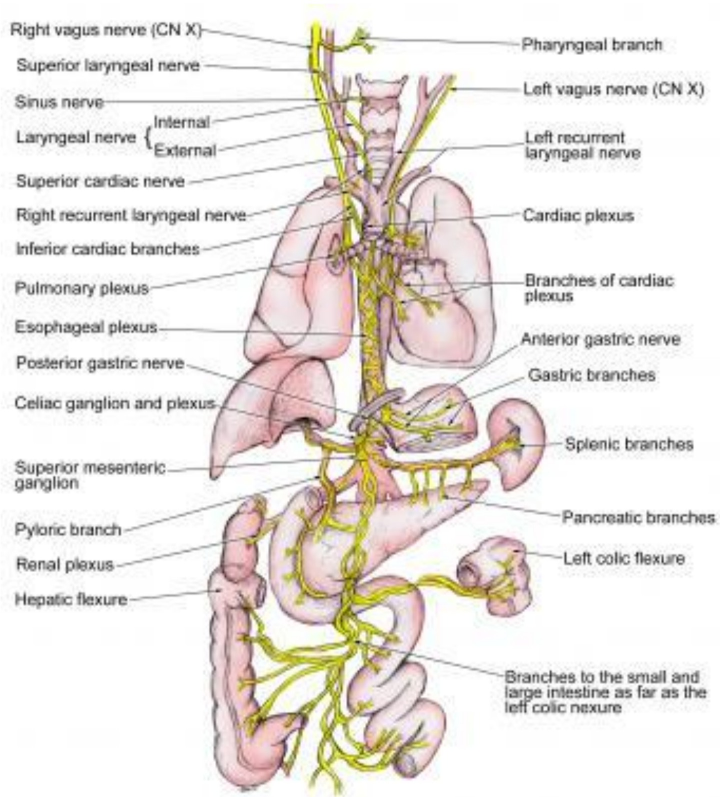
Course of the vagus nerve.

Course of the vagus nerve

The vagus nerve descends vertically within the carotid sheath posterolateral to the internal and common carotid arteries and medial to the internal jugular vein (IJV) at the root of the neck.

The right vagus crosses in front of the first part of the subclavian artery and then travels into the fat behind the innominate vessels. It then reaches the thorax on the right side of the trachea, which separates it from the right pleura. It then inclines behind the hilum of the right lung and courses medially toward the esophagus to form the esophageal plexus with the left vagus nerve. (See the image below.)

Diagram of the vagus nerve demonstrating the different branches.
The left vagus crosses in front of the left subclavian artery to enter the thorax between the left common carotid and subclavian arteries. It descends on the left side of the aortic arch,



which separates it from the left pleura, and travels behind the phrenic nerve. It courses behind the root of the left lung and then deviates medially and downwards to reach the esophagus and form the esophageal plexus by joining the opposite (right) vagus nerve.

The anterior and posterior gastric nerves are then formed from the esophageal plexus. The anterior gastric is formed mainly from the left vagus, but it does contain fibers from the right vagus.

Similarly, the posterior gastric nerve is formed mainly from the right vagus but contains fibers from the left vagus nerve. The gastric nerves supply all abdominal organs and the gastrointestinal tract ending just before the left colonic (splenic) flexure (see the images below).

Vagus nerve branches in the jugular foramen

The meningeal branch arises at the superior ganglion and reenters the cranium through the jugular foramen to supply the posterior fossa dura.

The auricular branch supplies sensations to the posterior aspect of the external ear (pinna) and the posterior part of the external auditory canal. It arises also from the superior ganglion and enters the mastoid canaliculus in the lateral part of the jugular foramen. It exits again through the tympanomastoid suture of the temporal bone to reach the skin. It communicates with branches of the seventh (facial) and ninth (glossopharyngeal) cranial nerves.

Vagus nerve branches in the neck

The branches in the next consist of the following:

- Pharyngeal branches
- Superior laryngeal nerve

- Recurrent laryngeal nerve
- Superior cardiac nerve

Pharyngeal branches

The pharyngeal branches arise from the inferior ganglion and contain sensory and motor fibers. The motor fibers are contributed by cranial nerve XI. They reach the middle constrictor muscle after crossing between the external and internal carotid arteries. They reach the pharyngeal plexus formed by cranial nerve IX and the sympathetic chain. Branches of the pharyngeal plexus supply the pharyngeal muscles and mucous membrane and palate except for the tensor palatini muscle.

The intercarotid plexus, at the carotid bifurcation, is also formed by vagal fibers from the pharyngeal plexus, joined by glossopharyngeal and sympathetic fibers. These vagal fibers and visceral afferents mediate impulses set up by the chemoreceptors in the carotid body.

Superior laryngeal nerve

The superior laryngeal nerve passes between the external and internal carotid arteries at the level of crossing of cranial nerve XII. At the tip of the hyoid, the superior laryngeal nerve divides into the external and internal branches. The internal laryngeal nerve pierces the thyrohyoid membrane to enter the larynx. The external nerve passes inferiorly with the superior thyroid vessels to the inferior pharyngeal constrictor muscle. The cricothyroid muscle is supplied by the external branch of the superior laryngeal nerve. The internal branch of the superior laryngeal supplies most of the mucosa above the glottis. It is divided into the following 3 divisions:

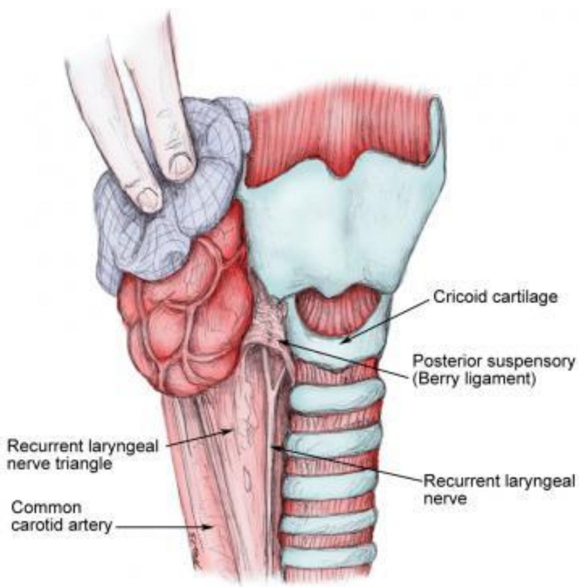
- First division - Supplies mucosa of the laryngeal surface of the epiglottis
- Middle division - Supplies the mucosa of the true and false vocal folds, as well as the aryepiglottic fold
- Inferior division - Supplies the arytenoid mucosa, anterior wall of the hypopharynx, upper esophageal sphincter, and part of the subglottis (the major part of the subglottis is innervated by the ipsilateral recurrent nerve)

Recurrent laryngeal nerve

The recurrent laryngeal nerve is also known as the inferior laryngeal nerve. The right nerve branches from the vagus at the root of the neck around the right subclavian artery. It courses superiorly in the tracheoesophageal groove to enter the larynx between the cricopharyngeus and the esophagus.

The left recurrent laryngeal nerve has a similar course to the right recurrent, except that it loops around the aortic arch distal to the ligamentum arteriosus.

The main trunk of the recurrent lies in a triangle bound laterally by the common carotid artery, the IJV, and the vagus nerve and medially by the trachea and esophagus. The recurrent nerve passes under the posterior suspensory ligament of Berry (located on either side of the trachea, extending from the cricoid cartilage and the first 2 tracheal rings to the posteromedial aspect of the thyroid gland), before entering the larynx (see the image below). A few variations may occur in this area (see Natural Variants).



Relation of the recurrent laryngeal nerve to the ligament of Berry.

All the intrinsic laryngeal musculature is supplied by the ipsilateral recurrent nerve except the cricothyroid muscle, which is supplied by the superior laryngeal nerve. The interarytenoid muscle is the only one that receives a bilateral supply (ie, from the left and right recurrent laryngeal nerves).

The ramus communicans, or nerve of Galen, connects the superior and the recurrent laryngeal nerves. It provides the tracheal and esophageal mucosa and smooth muscle with visceral motor input.

Superior cardiac nerve

The superior cardiac nerve is made up of 2-3 branches. They communicate with the sympathetic fibers.

Vagus nerve branches in the thorax

The inferior cardiac branch is also called the ramus cardiaci inferiors. On the right side, it arises from the trunk of the vagus as it lies beside the trachea. On the left side, it originates from the recurrent laryngeal nerve only. These branches end in the deep part of the cardiac plexus.

The anterior and posterior bronchial branches are distributed as 2-3 branches on the anterior surface of the root of the lung. They form the anterior pulmonary plexus after joining branches from the sympathetic trunk. The posterior bronchial branches are larger than the anterior and lie on the posterior surface of the root of the lung to form the posterior pulmonary plexus (with contributory sympathetic fibers) as well.

The esophageal branches are anterior and posterior branches. Together they form the esophageal plexus. The posterior surface of the pericardium is supplied by filaments from this plexus.

Vagus nerve branches in the abdomen

The gastric branches (rami gastrici) supply the stomach. The right vagus forms the posterior gastric plexus and the left forms the anterior gastric plexus. The branches lie on the posteroinferior and the anterosuperior surfaces, respectively.

The celiac branches (rami celiaci) are derived mainly from the right vagus nerve. They join the celiac plexus and supply the pancreas, spleen, kidneys, adrenals, and intestine.

The hepatic branches originate from the left vagus. They join the hepatic plexus and through it are distributed to the liver.

http://emedicine.medscape.com/article/1875813-overview

15. What are meninges and how do they protect the brain and spinal cord?

Definition of Meningitis

Meningitis is defined as inflammation of the meninges, which are the membranous layers that cover and protect the outside of the brain and spinal cord. Meningitis is painful and can be caused anything that triggers inflammation, including viral, bacterial, parasitic or fungal infections. Other causes are exposure to chemical toxins, infected bite wounds on the head and neck and bacterial migration to the brain from infected sinuses, nasal passages, middle ears or elsewhere. Dogs with meningitis have a high fever, stiff muscles, muscle spasms, hypersensitivity to touch and a stilted gait. They become depressed, lethargic and nauseous. Advanced cases of meningitis can cause extreme depression, blindness, progressive paralysis, seizures, confusion, agitation and/or aggression. Affected dogs may be unable to coordinate their movements, move in uncontrollable circles, stand up then stumble when trying to walk, or walk with their front legs spread far apart. Unfortunately, meningitis can be fatal.

Causes of Canine Meningitis

Most cases of canine meningitis are caused by secondary complications of diseases that start elsewhere in the body, including viral, protozoan, bacterial, parasitic or fungal infections. The causative agent can be anything that triggers inflammation in a particular dog. Some known causes are infected bite wounds on the head and neck and bacterial migration to the brain from infected sinuses, nasal passages, middle ears or elsewhere. Meningitis can also be aseptic, which means that it is caused by a non-bacterial disease of unknown origin. Aseptic meningitis tends to affect young, large-breed dogs between 4 and 24 months of age. Meningitis is an extremely serious condition that should not be taken lightly.

Preventing Meningitis

There is no way to prevent meningitis, other than preventing the underlying cause of the condition. As with most illnesses, a high-quality diet, free access to fresh water, good housing conditions and regular veterinary check-ups will support a healthy immune system in domestic dogs and reduce the risk of infectious disease.

Special Notes

Meningitis can be difficult to diagnose and to treat. The long-term prognosis for dogs with meningitis is generally poor.

Diagnostic Procedures

The signs of meningitis are often easy to detect. If a veterinarian sees a dog with fever, stiffness, painful spasms in the back, rigidity of the muscles of the neck and forelimbs and extreme sensitivity to touch (called "hyperesthesia"), she probably will begin her diagnostic process by running blood and urine tests to detect possible causes of those signs. If the results of those tests are normal, she may prescribe medications on the assumption that the signs are caused by meningitis. This is called diagnosis by response to treatment. If the medication works, then the dog probably was suffering from meningitis.

In some cases, the veterinarian or owner wants at least a tentative diagnosis before treatment begins. Very few tests are available to diagnose meningitis. They ones that are available include computed tomography (CT or CAT scan), magnetic resonance imaging (MRI) and cerebrospinal fluid (CSF) tap and sample assessment. Blood tests can also help to narrow down or possibly identify the actual cause of a dog's neurological condition. A CT/CAT scan or MRI, if available, will allow the veterinarian to visualize inflammation of the meninges, which are the tissue layers surrounding the brain and spinal cord. If inflammation is not seen, this will almost always rule out meningitis as a cause of the dog's clinical signs. Analysis of cerebrospinal fluid obtained by a spinal tap can be diagnostic as well. A sample of the cerebrospinal fluid which coats the brain and spinal cord can help with the diagnosis. This procedure involves collecting cerebrospinal fluid through a needle inserted between several of the vertebrae in the dog's back. The fluid is analyzed microscopically for evidence suggestive of meningitis. During this procedure, the dog will be under general anesthesia. These tests are expensive, and they are not widely available. The only way to truly definitively diagnose canine meningitis is by histopathologic examination of affected brain and/or spinal cord tissue, which is not normally done in a clinical setting. It usually is done post-mortem.

Special Notes

Meningitis is a life-threatening condition. If a dog displays signs consistent with meningitis, its owner should please make an immediate visit to a veterinarian. Early diagnosis is essential for successful treatment and recovery.

Overview

Steroid Responsive Meningitis is a condition that involves a dog's central nervous system. Meningitis means inflammation of the meninges, the covering layer of the central nervous system. The condition is referred to as SRMA, or steroid responsive meningitis-arteritis because it affects the arteries in many body system tissues as well.

Certain breeds of dogs seem to be more affected, but it is considered to be a condition of any breed. Bernese mountain dogs, Nova Scotia duck tolling retrievers, boxers, and beagles are among the over-represented breeds.

Symptoms of SRMA

The problem usually develops in young adults. Signs include fever, stiff neck, hyper-reactivity to touch, and reduced mobility due to marked stiffness. It can be acute or chronic. The cause is not well understood, but because it responds to steroid therapy, it is likely an autoimmune condition. Autoimmune problems occur when the body sees itself as foreign and mounts a reaction. There is the possibility that infectious agents can trigger this reactivity. Steroid medications have anti-inflammatory action, and at high doses, inhibit the immune system.

Diagnosing SRMA

The diagnosis of this condition can be a challenge and thorough physical and neurological examination, laboratory tests, spinal fluid analysis, X-rays, and CT scans may be recommended. Initial treatment includes supportive care and steroid medications. Long-term steroid administration is needed to control this condition. Some dogs need stronger immune system suppressant medication (immunosuppressives).

Effects of Meningitis

Meningitis is not a specific disease, but instead refers to the pathological condition of inflammation of the tissues surrounding and protecting the brain and spinal cord. The causative agent can be anything that triggers an inflammatory process in a particular dog, including bacteria, virus, fungus, chemical toxins and/or other agents. Meningitis is a very serious condition, and if a dog exhibits signs associated with this disorder it should be taken to a veterinarian immediately. Early diagnosis and treatment can lead to a successful outcome. Without treatment, the prognosis is poor.

Symptoms of Canine Meningitis

Most cases of canine meningitis happen as secondary complications of other diseases caused by bacterial infection. Dogs of any age, breed or gender can be equally affected. Newborn puppies seem to be especially at risk. With meningitis, the affected dog is almost always systemically ill. Clinical signs include one or more of the following:

- High fever (elevated body temperature)
- Muscle stiffness
- Muscle spasms in the back (often painful)
- Rigidity of the muscles of the neck and forelimbs (often painful)
- Extreme sensitivity to touch (hyperesthesia); may jump or yelp when touched
- Loss of appetite (anorexia; inappetence)
- Lethargy
- Nausea
- Vomiting
- Stiff, awkward stilted gait
- Inability to bend legs
- Head tilt
- High fever
- Depression
- Vision impairment/ blindness
- Progressive paralysis
- Seizures
- Confusion/disorientation
- Agitation
- Loss of coordination (ataxia)
- Aggression

Meningitis can be fatal. Advanced cases of meningitis can cause extreme depression, blindness, progressive paralysis, seizures, confusion, agitation and/or aggression. Severe cases can also cause ataxia, which basically means lack of muscular coordination. Affected dogs may be unable to coordinate their movements. They might move in uncontrollable circles, stand up then stumble when trying to walk, or stand and walk with their front legs spread abnormally far apart. The clinical signs of meningitis can mimic those of other disorders. In order to successfully diagnose meningitis in dogs, a series of tests and examinations will need to be performed by a skilled and perceptive veterinarian.

Dogs at Increased Risk

Dogs of any age, breed or gender can be equally affected. Newborn puppies are especially at risk. Affected animals are almost always systemically ill. They develop a high fever, a stiff awkward gait, painful back spasms, rigidity of the neck and forelimbs and extreme sensitivity to touch. They become lethargic, anorexic and nauseous. Advanced meningitis causes extreme depression, blindness, progressive paralysis, seizures, confusion, agitation, ataxia and/or aggression. It can be life-threatening

Treatment Options

Meningitis can be difficult to diagnose. If a veterinarian suspects that a dog has meningitis, she may recommend prophylactic treatment immediately, even before confirmatory diagnostic assessments are performed. The goals of treating canine meningitis are to suppress the inflammatory process, recover functional neurological abilities, relieve and manage pain and prevent or control seizures.

The standard treatment protocol begins with immunosuppressive doses of glucocorticoids ("steroids"), usually administered orally, to reduce swelling and inflammation of and around the brain. The most common form of meningitis in dogs is called "steroid responsive meningitis." It occurs most frequently in young adult, large-breed dogs. The cause of steroid responsive meningitis is unknown, but the disorder responds positively to oral steroid administration. How well a dog recovers depends upon the severity of the condition and whether it was treated before permanent damage to its body occurred. Dogs suffering seizures from meningitis can also be treated with anticonvulsants.

Other types of meningitis, including bacterial meningitis, are more difficult to treat. In those cases, high doses of antibiotic medications that cross the blood-brain barrier and achieve therapeutic concentrations within the cerebrospinal fluid must be administered in an attempt to kill the organisms causing the condition. Treatment for bacterial meningitis normally is long-term. It also is expensive and can be taxing on both the dog and its owner. If the dog has seizures associated with meningitis, antiepileptic drugs can be used. These also must be managed carefully.

Supportive care is extremely important in the treatment of meningitis. Intravenous or subcutaneous fluid therapy, nutritional supplementation, comfortable bedding, managed activity, free access to fresh water and appropriate pain medications are normally necessary to manage dogs with advanced cases of meningitis.

Owners of dogs that have been diagnosed with meningitis should have a frank discussion with their dog's veterinarian about available treatment and management options. In some instances, dogs recovering from meningitis need life-long physical therapy and medical treatment.

Prognosis

The prognosis for dogs with meningitis is variable, and can be guarded depending upon the dog's response to antibiotic treatment. Some dogs die despite treatment, while others recover completely. Of course, early diagnosis and aggressive treatment can dramatically improve a dog's chances of successful recovery.

http://www.petwave.com/Dogs/Health/Meningitis/Treatment.aspx

16. What is cerebrospinal fluid and how does it protect the brain and spinal cord?

Cerebrospinal fluid is fluid found in the subarachnoid space, surrounding the brain and spinal cord. The subarachnoid space is the area between the tough outermost membrane layer (called the dura mater) and the softer innermost layer (the pia mater) that covers the brain and spinal column. The fluid resembles serum, and its purpose is to maintain equal pressure within the brain and spinal cord. A cerebrospinal fluid (CSF) tap is the collection of this fluid for diagnostic purposes in dogs and other animals.

What Does A Cerebrospinal Fluid Tap Reveal in Dogs? Veterinarians collect a sample of this fluid to diagnose brain or spinal cord disease. It is typically performed to diagnose the cause of abnormal neurological signs such as seizures, altered mental status, and other abnormalities. It is often performed after advanced imaging techniques, such as computed tomography (CT scan) and magnetic resonance imaging (MRI) uncovers some abnormality in the central nervous system. Abnormalities may include inflammation, viral or bacterial infection, bleeding, or suspected tumors. A cerebrospinal fluid tap may also be performed to deliver pain-relieving medication prior to a surgical procedure. It may also be performed to inject dye in the spinal column to detect and abnormal position of the spinal cord. After the dye is injected, radiographs (x-rays) are taken, which is referred to as a myelogram.

How Is a Cerebrospinal Fluid Tap Performed in Dogs? There are two different types of spinal taps: a cisternal tap and a lumbar tap. To perform a cisternal tap, the back top of the neck is shaved and sterilized. A spinal needle is inserted at the base of the skull, and into the spinal column, penetrating the dura mater and arachnoid membranes to the subarachnoid space. A syringe is attached to the spinal needle to draw out the fluid. The fluid can also be allowed to drip into a collection tube. A lumbar tap (also called lumbar puncture) is performed in the lower back of a patient. The area is shaved and sterilized, and a spinal needle is inserted. A syringe is attached to the needle and fluid is withdrawn or the fluid is allowed to drip into a collection tube.

Is a Cerebrospinal Fluid Tap Painful to Dogs? Because the procedure is performed under general anesthesia, no pain is involved. There may be some pain and discomfort following the procedure. As with people, the pain experienced will vary among individual animals.

Is Sedation or Anesthesia Required? General anesthesia is necessary to perform the procedure. General anesthesia will induce unconsciousness, complete control of pain and muscle relaxation. Pets undergoing this procedure often receive a pre-anesthetic sedative-analgesic drug to encourage relaxation followed by a brief intravenous anesthetic to allow placement of a breathing tube in the windpipe, and subsequently inhalation (gas) anesthesia in oxygen during the actual procedure. Read more at: http://tr.im/YoB1y
http://www.petplace.com/article/dogs/diseases-conditions-of-dogs/tests-procedures/cerebrospinal-fluid-csf-tap-in-dogs

17. What is the brain stem?

What Are the Brain and Spinal Cord? The brain and the spinal cord comprise the central nervous system in a dog and other pets. The brain is the center for interpreting and integrating information from all over the body. The spinal cord acts as a conducting system to relay information from the brain to various areas of the body.

Where Are the Brain and Spinal Cord Located in Dogs? The brain is located within the bony cranium or the skull. The spinal cord is located within the spinal canal that runs through the vertebral column (neck and back bone), and extends from the base of the skull down the middle of the tail.

What Is the General Structure of the Brain and Spinal Cord? The brain is a mass of soft, pinkish gray nerve tissue divided into three major compartments: the brain stem, cerebrum and cerebellum.
Brain stem. The brain stem is located at the base of the brain and is connected to the spinal cord and cerebellum. Almost all of the cranial nerves (nerves that control various functions on the head) arise from the brain stem.
Cerebrum. The cerebrum, which forms the bulk of the brain, may be divided into two major parts: the right and left cerebral hemispheres. The hemispheres are divided by a narrow slit or cleft called the cerebral longitudinal fissure. The two sides of the brain are connected at the bottom by the corpus callosum, which delivers messages from one side to the other.
Cerebellum. The cerebellum is located at the back of the brain and is attached to the brain stem and cerebrum.

The cerebellum functions chiefly to coordinate movement and posture. The spinal cord is an elongated structure, more or less cylindrical, that is made up of the major bundle of nerve tracts that carry nerve impulses to and from the brain to the rest of the body. The spinal cord is connected to all areas of the body by nerves that leave and enter the spinal column through the gaps between the bony vertebrae. Both the brain and the spinal cord are enclosed within the meninges, which consists of three tough membranes called the dura mater, arachnoid and pia mater. Cerebrospinal fluid (CSF) is produced within the brain in hollow channels called ventricles. This fluid surrounds the brain and spinal cord to protect them from injury. Both brain and spinal tissue can be subdivided into gray matter and white matter. What Are the Functions of the Brain and Spinal Cord for Dogs? The brain governs various behaviors through learning, motivation and perception. It produces nerve impulses to make muscles move, to send signals to organs, and to control numerous automatic bodily functions. The brain also receives and registers sensory impulses, such as sight, sound, taste, touch, smell, and pain. The spinal cord acts to coordinate movement and muscular activity. It also governs both automatic and voluntary reflexes, such as blinking, scratching, twitching the ears, and wagging the tail.

What Are the Common Diseases of a Dog's Brain? Brain disorders can be subdivided into congenital abnormalities, infections, inflammations, degenerative diseases, metabolic disorders, vascular conditions, tumors, traumatic injuries, nutritional disorders, toxic conditions, and diseases of unknown cause. Some examples of brain diseases that occur in dogs are listed below: Hydrocephalus is the accumulation of cerebrospinal fluid within the ventricular system of the brain. As a result, the ventricles become enlarged and the brain matter shrinks from the fluid pressure. It may be primary and congenital, resulting from either increased production of CSF or failure of absorption. Hydrocephalus may also develop secondary to obstruction of the ventricles. Congenital cases most commonly occur in toy and brachycephalic breeds of dogs, such as the pug, Chihuahua, toy poodle, Lhasa apso, etc. Peripheral vestibular disease is a condition that affects both the brain and the nerves that control equilibrium. Dogs with vestibular disease have difficulty with balance and orientation. Signs include head tilt, falling and falling over. Canine idiopathic vestibular disease (also called "old dog vestibular disease") is a common form of the disease. Infectious encephalitis is inflammation of brain tissue caused by infectious organisms. In dogs it may be caused by viral diseases (canine distemper, infectious canine hepatitis, rabies), parasitic infestations, protozoal infections (toxoplasmosis, neosporosis, encephalitozoonosis), numerous bacteria, rickettsial organisms (ehrlichiosis, Rocky Mountain spotted fever, salmon poisoning), and fungal infections (blastomycosis, cryptococcosis, coccidioidomycosis). Seizures are abnormal brain activity that may result in convulsions that manifest as odd behaviors, tremors, muscles contractions, salivation and defecation. There are many causes of seizures such as epilepsy, which is a condition characterized by recurrent seizures. Epilepsy is found in many pure bred and mixed breed dogs. The Belgian tervuren is listed among the breeds for which a genetic factor is either proved or highly suspected. Other breeds with increased prevalence of epilepsy include the beagle, dachshund, German shepherd dog, boxers, collie, and Labrador retriever. Narcolepsy is a neurological disorder that induces extreme daytime sleepiness. It may be accompanied by cataplexy, which is characterized by sudden episodes of muscular weakness. Dogs are one of the few animals that suffer from narcolepsy. Brain tumors may be primary and arise from brain tissues, or they may be secondary and develop from either surrounding or distant tissues. Many different tumors can metastasize to the brain. Head trauma is a fairly common injury in dogs that are hit by cars or receive either blunt or penetrating injuries to the head. Clinical signs can vary widely depending upon the type of injury, but may include stupor, loss of consciousness, abnormalities in pupil size and the function of other cranial nerves, seizures, weakness, inability to walk, and head tilt.

What Are the Common Diseases of the Dog's Spinal Cord? Spinal cord disorders generally cause dysfunction of one or more limbs and/or the tail. Spinal cord disorders may occur alone or in combination with disorders of the brain. Like brain disorders, spinal cord diseases can be subdivided into congenital abnormalities, infections, inflammations, degenerative diseases, vascular conditions, tumors, traumatic injuries, nutritional disorders, toxic conditions, and diseases of unknown cause. Some examples of spinal cord diseases that occur in dogs are listed below: Spina bifida is a rare developmental anomaly characterized by defective closure of the two halves of the vertebra (back bone) through which the spinal cord may or may not protrude. It usually results in dysfunction of the tail and anus, incontinence and sometimes pelvic limb weakness. It is seen most commonly in "screw-tailed" breeds such as the English bulldog, but has also been reported in Rhodesian ridgebacks. Infectious meningitis is inflammation of the meninges of the brain or spinal cord, arising from some sort of infection. The most common causes of meningitis in dogs are bacterial infections, canine distemper virus infection, infectious canine hepatitis virus, and toxoplasmosis. Spinal tumors can occur in the vertebrae, the meninges, nerve roots and/or the spinal cord itself. Tumors that arise from cells within or covering the spinal cord are called primary tumors. Tumors arising from nearby tissues that invade or impinge upon the spinal cord are referred to as secondary tumors. Degenerative myelopathy is a slowly progressive disease characterized by loss of muscle coordination, weakness and thinning of the muscles, and eventual paralysis of the hind limbs. It is common in German shepherd dogs. Intervertebral disc disease arises with degenerative changes that result in protrusion of the discs of the vertebral column. As the discs put pressure on the spinal cord, certain clinical signs may be seen. These include pain, muscle weakness, partial or complete paralysis, and other neurologic deficits.

What Types of Diagnostic Tests Are Used to Evaluate the Brain and Spinal Cord? A complete neurologic examination including the testing of various reflexes provides valuable information on the function of the brain and spinal cord. Cerebrospinal fluid (CSF) analysis is the microscopic examination of CSF retrieved via a spinal tap. The analysis often provides valuable information as to the presence of infection, inflammation, and other abnormalities. X-rays provide information about the bony skull around the brain, and the vertebrae that surround the spinal cord. The brain and spinal cord themselves do not show up well on X-rays, but a special procedure called a myelogram can help highlight various areas of the spine. Computed tomography (CT scan or CAT scan) is a special X-ray technique that provides serial images of the brain and spinal cord using enhanced computer processing. Magnetic resonance imaging (MRI) uses the properties of certain tissues subjected to extremely powerful magnetic fields to generate detailed images of body organs. MRI is a very useful tool in evaluating both the brain and spinal cord. Various electrodiagnostic tests are available to assess different functions of the brain and spinal cord. Such tests include the brain stem auditory evoked response (BAER), which is used to detect deafness; the electroencephalogram (EEG), which may detect abnormalities in brain activity during a seizure disorder; and nerve conduction velocity (NCV), which assesses the function of peripheral nerves. Read more at: http://tr.im/thWBv
http://www.petplace.com/article/dogs/diseases-conditions-of-dogs/body-structure-function/structure-and-function-of-the-brain-and-spinal-cord-in-dogs

18. What brain and the spinal cord make up the central nervous system. What is its function?

In a dog's nervous system, electrical impulses travel via nerve fibers, which deliver messages to cells and organs. Chemical transmitters are also used for communication between different nerve cells and other *tissues* they communicate with. The nervous system is a very complex network.

Anatomy

Central Nervous System: In mammals, the nervous system is divided into several segments. The central nervous system (CNS) is made up of the brain, brain stem, and spinal cord. The peripheral nervous system (PNS) includes the nerves that run from the brain to areas of the head and neck, and also those nerves exiting and entering the spinal cord. These nerves carry messages from the CNS to other body areas 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.

Peripheral Nervous System: Peripheral nerves that go from the brain or spinal cord are called motor nerves. These nerves affect muscles, i.e., 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 back to the central nervous system.

Autonomic Nervous System: Another set of nerves comprise the autonomic nervous system (ANS). The ANS (which arises from the CNS) 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.

Development of the nervous system

Coordinated Movement: A puppy is born without a fully developed nervous system. The brain, spinal cord, and associated nerves are present at birth but lack the capacity to adequately transmit electrical impulses in a coordinated fashion. As the nervous system matures in the initial weeks of life, a series of nerve controlled events begin to become evident. During the first week of life, it seems that puppies do little but eat and sleep. They do have some motor activity, moving even while seemingly sound asleep. By the second week of life a puppy still spends a great deal of time sleeping, but the sleep becomes quieter or more restful with fewer body movements. Awake moments are typically spent nursing. By three weeks of age, most puppies can maintain an upright posture and begin to spend more time awake. They attempt to move by pushing or sliding, as they are still unable to stand and walk. The initial attempts at 'crawling' are usually short as the muscles are not strong. After three weeks of age, the puppy will develop the ability to stand and perhaps walk short distances. Eventually, over the next few weeks, the puppy becomes fully mobile and able to walk and even run in a clumsy sort of fashion.

Vision: Puppies are born blind with closed eyelids. The eyelids open by fourteen days of age, exposing the eyeball which now is only mildly sensitive to light. Most puppies will have vision by three to four weeks of age, but it will not be fully developed until after ten weeks of age.

Hearing: Puppies are born deaf as well as blind. Just like the eyelids, the *ear canals* remain closed until about two weeks of age. At about two weeks of age, most puppies can hear some noises. At this age, they are easily startled by sharp noises. By four weeks of age, most puppies will hear the sounds without becoming startled. Puppies over four weeks of age can hear quite well.

All of the above developments, the walking, vision, and hearing, are controlled by the nervous system. The exact age at which these abilities develop is variable. The ages mentioned are the average, not the rule.

Disorders of the nervous system

Nervous system disorders may result from improper development of the nervous tissue and its associated organs, or from damage due to trauma or infections. Many conditions exist which are genetic in origin.

http://www.peteducation.com/article.cfm?c=2+2083&aid=329

19. Why is it important to gently "HUG and HOLD" during the ABP Move?

It is important to gently hug and hold during the ABP moves because this is where the brain and body begins to communicate. It allows the muscles and body to relax.

First Response Bowen pg.34

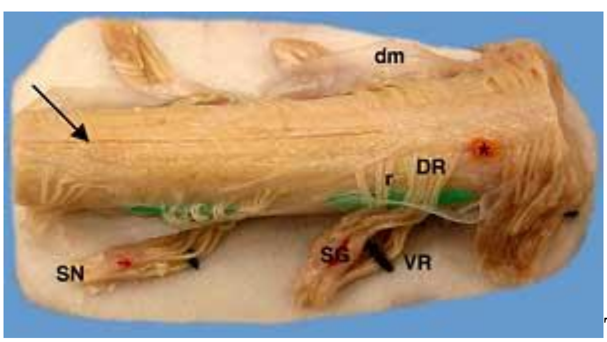
20. What is the importance of the wait time?

It is important to have the wait time to allow the brain to process the new information.

21. Describe the spinal card in detail.

Spinal Cord Gross Anatomy

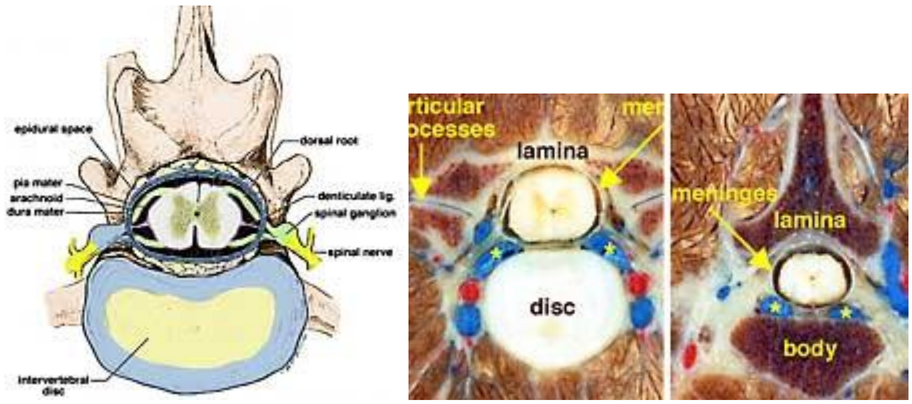
The **spinal cord** is a long cylinder of nervous tissue with subtle cervical and lumbar (lumbosacral) enlargements. The enlarged segments contribute to the brachial and lumbosacral plexuses. In the above image, showing a brain and spinal cord from a neonatal pig, the spinal cord and spinal roots are enveloped by dura mater.



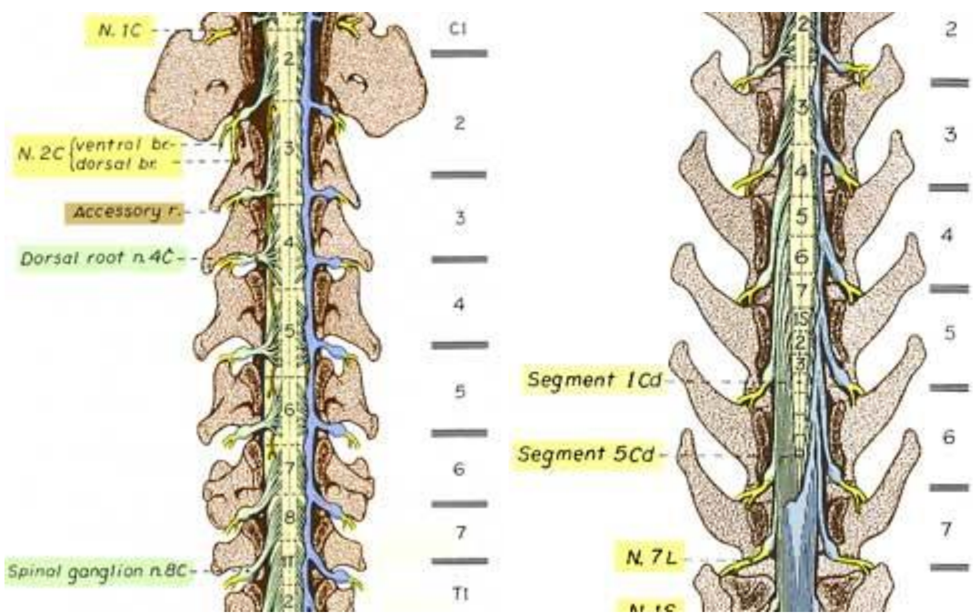
The spinal cord is divided into **spinal cord segments**. Each segment gives rise to paired spinal nerves (click left image). Dorsal and ventral **spinal roots** arise as a series of rootlets. A **spinal ganglion** is present distally on each dorsal root. The canine spinal cord has 8 cervical, 13 thoracic, 7 lumbar, 3 sacral and 5 caudal segments. The following table compares species.

Spinal cord segments in different species (for reference purposes):

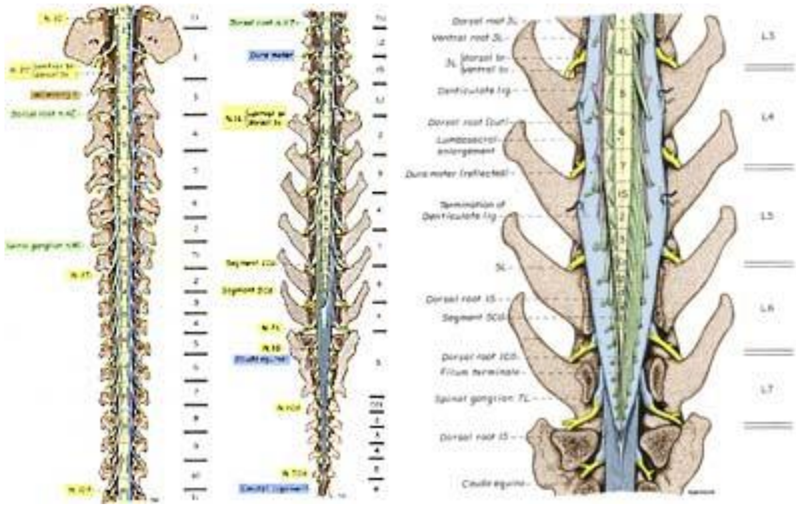
Dog: 8 cervical; 13 thoracic; 7 lumbar; 3 sacral; & 5 caudal = 36 total
Cat: 8 cervical; 13 thoracic; 7 lumbar; 3 sacral; & 5 caudal = 36 total
Bovine: 8 cervical; 13 thoracic; 6 lumbar; 5 sacral; & 5 caudal = 37 total
Horse: 8 cervical; 18 thoracic; 6 lumbar; 5 sacral; & 5 caudal = 42 total
Swine: 8 cervical; 15/14 thoracic; 6/7 lumbar; 4 sacral; & 5 caudal = 38 total
Human: 8 cervical; 12 thoracic; 5 lumbar; 5 sacral; & 1 coccygeal = 31 total



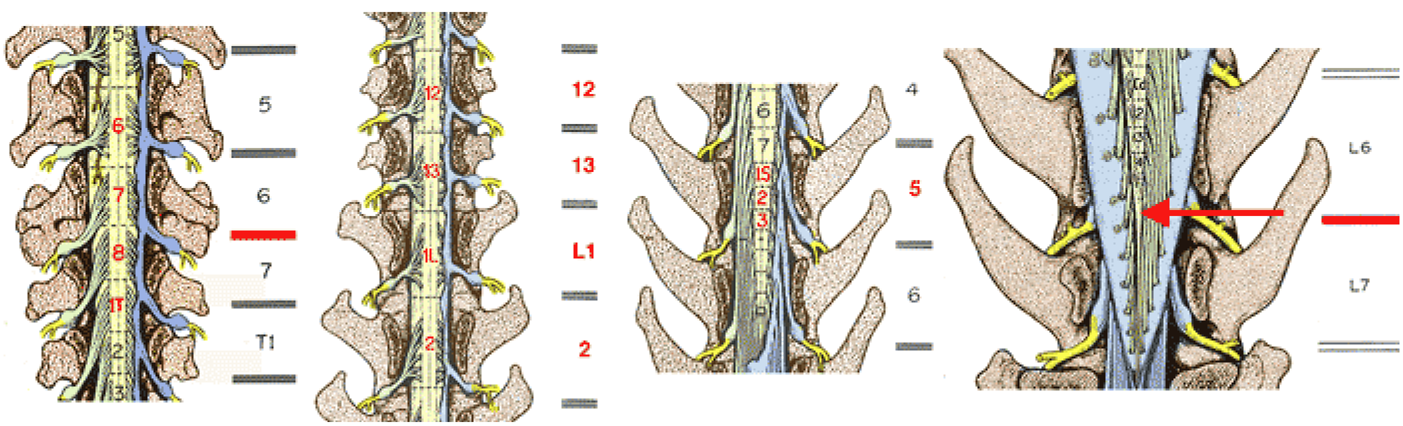
The spinal cord and spinal roots are enveloped by meninges and housed within the vertebral canal. The **epidural space**, situated between the wall of the vertebral canal and the spinal dura mater, contains a variable amount of fat. Within **dura mater**, the spinal cord is suspended by bilateral **denticulate ligaments** and surrounded by **subarachnoid space** filled with **cerebrospinal fluid**. Dorsal and ventral spinal roots unite to form spinal nerves which exit the vertebral canal at intervertebral foramina. An intervertebral foramen is formed by adjacent vertebrae and by the intervertebral disc joining the vertebrae.



As a result of differential growth of the spinal cord and vertebral column, most **spinal cord segments** are positioned cranial to their nominally corresponding vertebrae. However, spinal segment length is variable along the spinal cord in our domestic mammals. Segments become progressively shorter from the C3 to T2. Then they elongate so that segments at the thoracolumbar junction are within nominally corresponding vertebrae. Thereafter, segments progressively shorten until the cord terminates in a **terminal filament** of glia. (The term "conus medullaris" refers to the cone-shaped cord region between the lumbosacral enlargement and the glial filament.)



Since spinal nerves exit the vertebral canal at nominally corresponding intervertebral foramina, **spinal roots** must elongate when spinal cord segments are displaced cranially. The term **cauda equina** (horse tail) refers to caudally streaming spinal roots running to intervertebral foramina in the sacrum and tail. Damage to the cauda equina affects pelvic viscera and the tail. Cauda equina epidural anesthesia (putting anesthetic into the epidural space to block conduction in spinal roots) is a common obstetrical procedures in cattle.



Because vertebrae can be palpated and visualized in ordinary radiographs, unlike spinal segments, it is clinically useful to know locations of spinal cord segments relative to vertebrae. Typically (for most dogs) the cervical enlargement is centered at the C6-7 intervertebral disc; spinal segments of the thoracolumbar junction are within nominally corresponding vertebrae; the sacral segments are within vertebra L5; and the functional spinal cord terminates at the L6-7 vertebral junction. (Termination is about one vertebra further caudally in small dogs, less than 7 kg.)

http://vanat.cvm.umn.edu/neurLab2/SpCdGross.html

22. What can a spinal cord injury cause in a canine? Mild/Moderate/Severe

Dog Spinal Cord Injuries

Of course, the spinal cord is a continuation of the brain and as such has many of the problems associated with the brain as well as many unique to itself.

Compression. The most common problem with the spinal cord is compression. The suddenness of the onset is all important since gradual compression can be compensated for, whereas sudden compression,although no worse, may produce paralysis. This is due to the inflammation associated with a problem severe enough to suddenly compress the spinal cord.

In the Dachshund, perhaps because of the elongated spinal bones,there is a predisposition to ruptured inter vertebral disks with paresis,paralysis, or paraplegia. In this situation the compression of the spinal cord must be treated promptly with either medication and rest or with surgery and rest. There are several surgical procedures but time is important since excess pressure on the spinal cord will produce necrosis after a few days. Radiography is imperative for diagnosis in such cases.

Congenital Spinal Cord Problems. Not unusual are congenital spinal cord problems, but they are rarely diagnosed until the puppy is eight weeks of age or older. Some conditions, such as one found in German Shepherds called degenerative mycelia, arc not observe din dogs under six years of age and usually in those over ten. These conditions do not lend themselves to either surgical or medical treatment.

Tumors. Spinal cord tumors are not a rare finding and treatment is usually unsuccessful. Tumors produce insidious signs as they develop and may be difficult to prove in their early stages even with X rays.Even a minute lesion causes signs depending on its location. In time as the lesion grows, radiographs prove its presence and delicate surgery is the only possible way to deal with it.

Traumatic Injury. Of the traumatic causes of injury to the spinal cord, automobile accidents head the list. The tragedy of the dog lying on its side on the road with front legs in full extension is all too com-mon. The rigid extension of the forelegs usually indicates a spinal cord injured beyond repair. X rays reveal the fracture with displacement indicating a severed spinal cord. However, the cord may be sheared off with the fracture, returning to an almost normal position. Animals in this condition should be humanely put to sleep. Surgery to relieve pressure in less severe cases is well worth the chance in a loved pet.

Chaste Paralysis. Chaste paralysis separately because it is a distinct form of paralysis with a known cause. It is produced by the consumption of raw fish in quantity. In raw fish there is a vitaminB1 (thiamin) in activator; therefore the disease is really a thiamin deficiency. It is relieved by adding the vitamin to the diet and by feeding the dog only cooked fish, since cooking destroys the in activator.

Other Possible Causes of Paralysis. Several other factors are known to produce paralysis. Mineral deficiency and inadequate protein may be involved with central nervous problems including paralysis. Moreover, blows to the spine, auto intoxication from long spells of constipation, great accumulations in the anal glands, and damage from many other diseases may cause nerve problems.

If you find your dog suddenly paralyzed, gently put it on a flat sr-face and take it to the veterinarian. The veterinarian may be able to operate on a brokers back or a ruptured inter vertebral disk, and if the spinal cord has not been too severely injured, your pet may be well again in time.

If your dog has developed paralysis slowly, your veterinarian is apt to suggest treatment. And here more devoted nursing is needed than in any other ailment your dog may have. Start with the possibility in mind that recovery to normal may never occur. Bc grateful for every bit of improvement shown. You may have to build a carriage for your pet's rear quarters. The dog will have to be kept on some soft absorbent material that must be changed frequently or the urine passed may burrs the skin. Bedsores develop easily. Feces must be removed. There maybe just enough innervating in the back legs to hold its weight. This simplifies matters greatly, because a dog can be taken outside and taught to urinate and defecate when pressure of your fingers is applied over its bladder on each side of the abdomen. A dog whose legs can support its weight is a good patient and remains housebroken, but completely paralyzed dog requires great care and only a loving master will have the patience to see such an illness through.

Definite nerve destruction on a large scale cannot be repaired, and the posterior paralysis following distemper unfortunately is often hope-less. Your veterinarian will he able to give you some idea of the extent and progress of the disease.

http://www.petcaregt.com/dogcare/dogspinalcordinjuries.html

23. Malformations in the spinal card can affect motor function. What are some of these malformations and where along the spinal cord to they appear?

Spinal and Vertebral Birth Defects in Dogs

Congenital Spinal and Vertebral Malformations in Dogs

Dogs most often genetically inherit congenital spinal and vertebral malformations (as opposed to adverse conditions during fetal development). Specifically, sacrococcygeal dysgenesis (defective development) is a dominant trait, while thoracic hemivertebra (chest half-vertebra) of German shorthaired pointers is a recessive trait.

Spinal malformations are usually evident at birth or in the first few weeks of life. On the other hand, vertebral malformations can be latent until the dog undergoes a growth spurt around five to nine months of age. Visible signs of a distorted spinal column are lordosis (curvature of the spine at the lower back) and kyphosis (a posterior curvature of the spine).

Scoliosis (a lateral curvature of the spine) is also an easily visible form of vertebral malformation. If the malformations lead to secondary spinal cord compression and trauma, the affected dog will display ataxia and paresis. Medicine often does not resolve neurological manifestations of spinal and vertebral malformations. If the condition is severe and untreatable, euthanasia should be considered.

Symptoms and Types

- Malformation of the occipital bones – atlas and axis (the first and second cervical vertebrae at the base of the skull):
    - Causes compression of the upper spinal cord, which can lead to paralysis, sudden death
    - More common in small-breed dogs
- Hemivertebra (half a vertebra)
    - Kyphosis, scoliosis, lordosis
    - Wedge shaped vertebrae, causes angle in the spine
    - Most likely to affect the neurological system
    - Rear limb weakness (paraparesis), paralysis

    - May remain without symptoms
    - Affects breeds with a short skull, and “screw-tailed” breeds (may be desired in some breeds)
    - Pugs, Boston terriers, French and English bulldogs
- Transitional vertebra
    - Has characteristics of two types of vertebrae
    - May result in cord compression, disc changes
- Block vertebra
    - Fused vertebrae due to improper segmentation of vertebrae
    - Animal may live normally without symptoms
- Butterfly vertebra (vertebra with a cleft through the body and a funnel shape at the ends):
    - Vertebra with a cleft through the body and a funnel shape at the ends (giving appearance of butterfly on X-ray examination)
    - Causes instability of the vertebral canal, and rarely, compression of the spinal cord with paralysis
- Sacrococcygeal dysgenesis
    - Defective formation of lowest vertebrae in the spine
    - Associated with spina bifida (lack of vertebral arches in the spinal column)
- Spina bifida
    - Variable spinal dysplasia (abnormal development); dysraphism (defective spinal fusion); syringomyelia (cyst in the spinal cord); hydromyelia (enlarged central canal in the spinal cord where excess cerebrospinal fluid builds up); and myelodysplasia (defective development of the bone marrow)
    - Dog may not show symptoms
    - Bulldogs, pugs, Boston terriers
- Myelodysplasia
    - Defective development of the bone marrow
    - Weimaraners
- Congenital spinal stenosis (narrowing of the spinal canal - malformation from birth, hereditary)
    - Chondrodystrophic (dwarf) breeds
    - Basset hound, beagle, dachshunds, lhasa apso, shih tzu, Pekingese
    - Doberman pinschers are also genetically disposed

Causes

- Genetic inheritance
- Possibly, exposure of pregnant bitches to:
    - Compounds causing birth defects during fetal development
    - Toxins
    - Nutritional deficiencies
    - Stress

Diagnosis: You will need to give your veterinarian a thorough history of your dog's health and onset of symptoms. A full physical exam will be performed. X-rays of the spinal column (including all vertebrae) can often reveal the exact malformation. If neurological signs (paralysis) are present, a myelography can be used to indicate with precision at which level the spinal cord is compressed. This imaging technique uses a radiopaque substance that is injected into the spine, or into the membranous space that surrounds the spinal cord so that the defects in the spine will be visible on X-ray projections.

Computed tomography (CT) and magnetic resonance imaging (MRI) may also be helpful, and are in some cases much more sensitive than X-rays. However, myelography is generally the diagnostic imaging technique of choice.

Treatment: Surgery can be helpful for cases involving narrowing of the spinal canal and decompression of the spinal cord. Secondary damage due to spinal compression may be avoided if surgical intervention takes place early on. If the spinal compression is diffuse or long-term, your dog may not respond to surgery. If your dog is showing neurological signs such as dizziness, seizures or paralysis postoperatively, restricted activity combined with physical therapy may be helpful.

www.petmd.com

Spinal Column Malformation in Dogs

Atlantoaxial Instability in Dogs

Atlantoaxial instability results from a malformation in the first two vertebrae in the neck of an animal. This causes the spinal cord to compress and results in pain or even debilitation for the pet. The disorder is uncommon in older dogs and larger breeds of dogs. It is generally found in smaller, toy breeds. To ensure the best possible chance for a full recovery, it is important to treat the animal once an occurrence or sign of distress is observed.

The condition or disease described in this medical article can affect both dogs and cats. If you would like to learn more about how this disease affects cats, please visit this page in the PetMD health library.

Symptoms and Types: Dogs suffering from atlantoaxial instability may collapse frequently or even suffer from paralysis, depending on the severity of the spinal cord injury. Many animals also exhibit severe neck and back pain and a lack of desire to exercise.

Causes: The most common cause of atlantoaxial instability is an abnormal formation of ligaments in the animal's vertebrae, often leading to fractures. The formation may also be the consequence of an accident, especially for smaller dogs that jump from tall structures.

Diagnosis: The veterinarian will look for signs of trauma, seizures, tumors (neoplasia), severe exercise intolerance, and disk herniation. An X-ray or radiograph of the animal's spine may be taken to see if there are any injuries to the neck or spine. In addition to radiographs, CAT scans (computed tomography) may be used to view the soft tissue structures in the dog’s neck and spine. If the disorder goes untreated, it often leads to acute spinal cord trauma, respiratory arrest, and possible death.

Treatment: If your dog only experiences mild neck pain, a brace and confinement may be recommended. If it experiences neck pain along with other neurological symptoms, surgery is often the best course of action. The top (dorsal) approach involves the use of a wire or other synthetic material to fix the vertebral abnormalities. The underside (ventral) approach involves the use of a bone graft to repair the damage. The ventral approach is often considered the more stable approach in damage repair.

Living and Management: For the best chance of recovery, it is recommended to treat your dog quickly after distress is observed, and immediately after a trauma. If surgery is prescribed, younger dogs whose movements are restricted generally experience full recovery. Physical rehabilitation following treatment is important for a full recovery, benefiting neurological functions as well.

Prevention: Preventing your dog from leaping from tall structures will reduce the incidence of spinal and neck injuries. As most cases are present at birth (congenital), preventative measures are limited.

http://www.petmd.com/dog/conditions/musculoskeletal/c_multi_atlantoaxial_instability?page=show#

Disease	Typical breeds	Age	Onset	Neurological signs	Spinal pain
Atlantoaxial Instability (Subluxation)	Mainly toy or small; Yorkshire terrier, Poodle	Typically young, <2yrs	Acute or chronic	Common, obvious ataxia and paresis	Present in most cases
Hansen Type I disc disease	Any, mainly small breeds	>2yrs	Acute	Mild or absent	Severe
Hansen Type II disc disease	Any, mainly large breeds	>2yrs	Chronic	Mild to moderate	Mild to moderate
Cervical spondylomyelopathy (bone-associated)	Great Dane, other giant breeds	<4yrs	Usually chronic	Common, obvious ataxia and paresis	Mild
Cervical spondylomyelopathy (disc-associated)	Dobermann, other large breeds	>2yrs	Usually chronic	Common, obvious ataxia and paresis	Mild
Fibrocartilaginous embolism	Any	Any	Acute	Common, can be asymmetrical	None
Spinal trauma	Any	Any	Acute	Common	Common
Steroid responsive meningitis-arteritis	Boxers, beagles, any	Young, <2yrs	Acute or chronic	None	Severe
Acute non-compressive nucleus pulposus extrusion	Any	Any	Acute	Common, can be asymmetrical	None

http://www.vetsonline.com/images/ac5/ee7ec7aa90072d3d30a8fc248361e.jpg

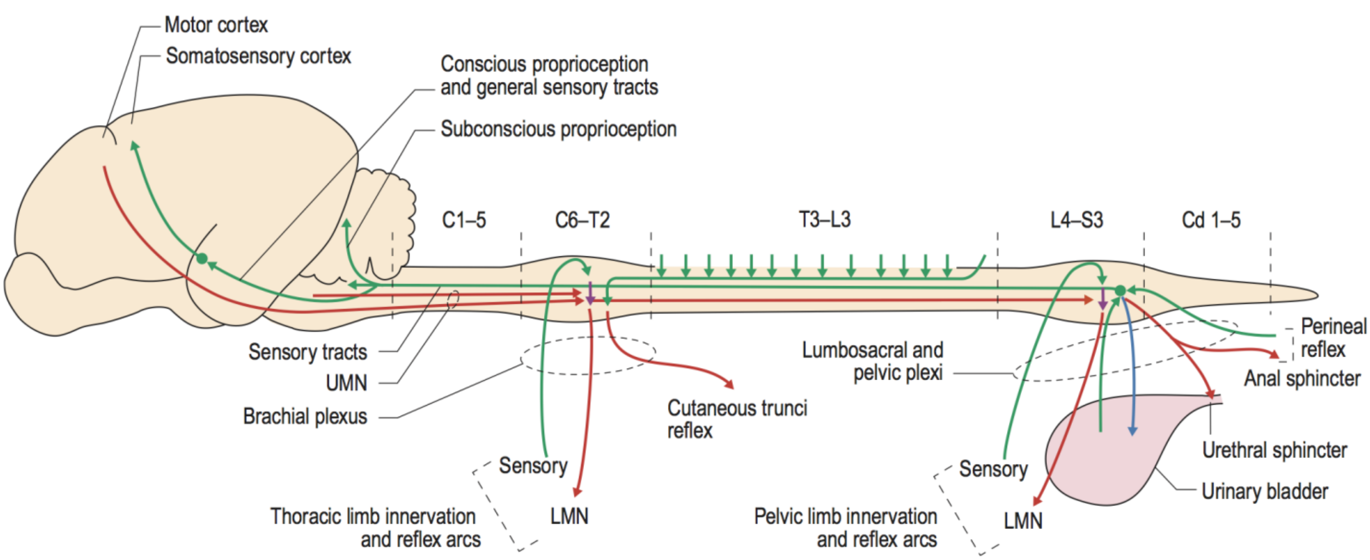


Fig. 13.15 **NeuroMap of the spinal cord. Green indicates sensory systems (conveying tactile, thermal, proprioceptive and nociceptive stimuli), red identifies motor systems and blue identifies autonomic systems. UMN = upper motor neuron, LMN = lower motor neuron**

http://classconnection.s3.amazonaws.com/831/flashcards/2835831/png/neuromap_-_spinal_cord-14475C387BA6F63B0A1.png

24. What is the peripheral nervous system?

In a dog's nervous system, electrical impulses travel via nerve fibers, which deliver messages to cells and organs. Chemical transmitters are also used for communication between different nerve cells and other *tissues* they communicate with. The nervous system is a very complex network.

Anatomy

Central Nervous System: In mammals, the nervous system is divided into several segments. The central nervous system (CNS) is made up of the brain, brain stem, and spinal cord. The peripheral nervous system (PNS) includes the nerves that run from the brain to areas of the head and neck, and also those nerves exiting and entering the spinal cord. These nerves carry messages from the CNS to other body areas 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.

Peripheral Nervous System: Peripheral nerves that go from the brain or spinal cord are called motor nerves. These nerves affect muscles, i.e., 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 back to the central nervous system.

Autonomic Nervous System: Another set of nerves comprise the autonomic nervous system (ANS). The ANS (which arises from the CNS) 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.

Development of the nervous system

Coordinated Movement: A puppy is born without a fully developed nervous system. The brain, spinal cord, and associated nerves are present at birth but lack the capacity to adequately transmit electrical impulses in a coordinated fashion. As the nervous system matures in the initial weeks of life, a series of nerve controlled events begin to become evident. During the first week of life, it seems that puppies do little but eat and sleep. They do have some motor activity, moving even while seemingly sound asleep. By the second week of life a puppy still spends a great deal of time sleeping, but the sleep becomes quieter or more restful with fewer body movements. Awake moments are typically spent nursing. By three weeks of age, most puppies can maintain an upright posture and begin to spend more time awake. They attempt to move by pushing or sliding, as they are still unable to stand and walk. The initial attempts at 'crawling' are usually short as the muscles are not strong. After three weeks of age, the puppy will develop the ability to stand and perhaps walk short distances. Eventually, over the next few weeks, the puppy becomes fully mobile and able to walk and even run in a clumsy sort of fashion.

Vision: Puppies are born blind with closed eyelids. The eyelids open by fourteen days of age, exposing the eyeball which now is only mildly sensitive to light. Most puppies will have vision by three to four weeks of age, but it will not be fully developed until after ten weeks of age.

Hearing: Puppies are born deaf as well as blind. Just like the eyelids, the *ear canals* remain closed until about two weeks of age. At about two weeks of age, most puppies can hear some noises. At this age, they are easily startled by sharp noises. By four weeks of age, most puppies will hear the sounds without becoming startled. Puppies over four weeks of age can hear quite well.

All of the above developments, the walking, vision, and hearing, are controlled by the nervous system. The exact age at which these abilities develop is variable. The ages mentioned are the average, not the rule.

Disorders of the nervous system

Nervous system disorders may result from improper development of the nervous tissue and its associated organs, or from damage due to trauma or infections. Many conditions exist which are genetic in origin.

http://www.peteducation.com/article.cfm?c=2+2083&aid=329

25. Describe the PNS function.

Overview of the Nervous System

The nervous system is composed of billions of neurons with long, interconnecting processes that form complex integrated electrochemical circuits. It is through these neuronal circuits that animals experience sensations and respond appropriately.

Neuronal processes that transmit electrical alterations to the neuron cell body are called dendrites. Dendrites have receptor sites that receive stimulation or inhibition from outside sources. If electrical stimulation of the cell body reaches a critical threshold, an electrical discharge called an action potential develops. The action potential spontaneously travels away from the cell body along an outgoing process called an axon. When the action potential reaches the terminal branches of the axon, chemicals called neurotransmitters are released. Neurotransmitters either stimulate or inhibit receptor sites on other neurons, muscles, or glands. Although neurons may have a variety of shapes, each one has dendrites, a cell body, and an axon and releases neurotransmitters.

BASIC SENSORY AND MOTOR FUNCTIONS

The peripheral nervous system (PNS) s formed by neurons of the cranial and spinal nerves. The central nervous system (CNS) is formed by neurons of the spinal cord, brain stem, cerebellum, and cerebrum.

Groups of neuronal cell bodies in the PNS are called ganglia, whereas those in the CNS are called nuclei. Nuclei form the CNS gray matter. Groups of axons in the CNS form the white matter and are arranged into tracts. The tracts are usually named after their site of origin and termination (eg, the spinocerebellar tract begins in the spinal cord and ends in the cerebellum).

PNS sensory or afferent neurons carry information such as nociception, proprioception, touch, temperature, taste, hearing, equilibrium, vision, and olfaction to the spinal cord or brain stem. CNS sensory neurons carry information to the cerebellum, brain stem, and cerebrum for further interpretation. Important spinal cord and brain-stem sensory tracts include several spinocerebellar, spinothalamic, and spinoreticular tract systems. The spinoreticular tracts begin in the spinal cord and terminate in the reticular formation of the medulla. The dorsal fasciculi gracilis and cuneatus of the spinal cord and the medial and lateral lemniscus of the brain stem are also important sensory tracts. In animals, these sensory tracts may carry fibers from many sensory modalities such as proprioception, nociception (pain), and touch. An alteration in sensation may be due to either CNS or PNS disease.

Reactions to sensory inputs are initiated by efferent or motor neurons in the cerebrum and brain stem called upper motor neurons (UMNs). The UMN axons descend to brain-stem and spinal cord segments in tracts named after their site of origination and termination.

The UMNs of the reticulospinal tracts (from midbrain, pons, and medulla oblongata reticular formation) and the rubrospinal tract (from midbrain) are important for voluntary movements of skeletal muscles in domestic animals. The rubrospinal tract mainly functions to facilitate flexors of the limbs, whereas the pontine and medullary reticulospinal tracts have either a facilitative (pontine) or inhibitory (medullary) effect on the extensors. The corticospinal tracts (cell bodies in the cerebral cortex) are most important for voluntary movement in primates. Domestic animals with severe cerebrocortical disease may suffer only transient loss of voluntary movements, because their corticospinal tract has limited influence.

The pontine reticulospinal (from the pons) and vestibulospinal tracts (from vestibular nuclei of the medulla oblongata) facilitate extensor skeletal muscle activity used to support the body. Knowledge of location and function of sensory and motor brain-stem and spinal tracts is essential to localize nervous system lesions and determine their severity. Mild spinal cord compression affects the superficial spinal cord tracts fasciculus gracilus, cuneatus, spinocerebellar, and vestibulospinal tracts, so initial signs include ataxia and extensor weakness. Important voluntary motor tracts are located in the lateral portions of the spinal cord deep to the spinocerebellar tracts, and paresis or paralysis develops with moderate spinal cord compression. Because many tracts are involved, loss of nociception from the periosteum of the toes and tail (deep pain) occurs when spinal cord lesions are bilateral and severe. This loss of nociception is also an indicator of severe cord injury because those fibers that transmit deep pain are typically nonmyelinated, slow-transmitting C type fibers, which are very resistant to pressure.

Motor neurons with cell bodies in the brain stem, and spinal cord gray matter and axons that travel in the PNS cranial and spinal nerves, respectively, are referred to as lower motor neurons (LMNs). Injury to either the UMNs or LMNs results in paresis or paralysis. Brain-stem and spinal cord reflexes are the phylogenetically oldest responses of the nervous system. When the eyelid is touched, it closes; when the toe is pinched, the limb withdraws even before conscious perception intervenes. Only a sensory neuron in the PNS, a connector (internuncial) neuron in the CNS, and an LMN are necessary for a reflex to be present. In a monosynaptic reflex (eg, patellar reflex), only a sensory neuron and LMN are present. During the neurologic examination (see Physical and Neurologic Examinations), testing brain-stem and spinal reflexes is helpful to localize CNS and PNS lesions to specific areas. If a reflex is depressed or absent, a lesion must involve the sensory nerve, internuncial neuron, LMN, or muscle at that particular site.

The autonomic nervous system is divided into sympathetic and parasympathetic portions and controls activity in smooth and cardiac muscles and glands. Visceral afferent (sensory) neurons travel in cranial and spinal nerves and sensory spinal cord tracts to the thalamic and hypothalamic regions of the brain stem. UMNs in the hypothalamus descend to LMN cell bodies of the brain-stem nuclei and sacral segments for parasympathetic control and to the intermediolateral gray matter of the spinal cord for sympathetic control.

LMNs of the sympathetic nervous system exit through thoracolumbar spinal nerves (T1 to L4) to affect smooth muscles associated with the pupils, eyelids, orbits, hair follicles, blood vessels, and thoracic and abdominal viscera. Horner syndrome (ptosis, miosis, and enophthalmos) is a common finding associated with loss of sympathetic innervation to the eye.

LMNs of the parasympathetic nervous system exit via cranial nerve (CN) III to innervate smooth muscle of the pupils and eyelids, CN VII to the lacrimal and salivary glands, CN IX to salivary glands, and CN X to cardiac muscles and glands and to smooth muscles of all the thoracic and abdominal viscera to the level of the transverse colon. LMNs of the parasympathetic nervous system also exit through the sacral segments to all the viscera in the caudal abdomen, including the bladder and colon. Sacral lesions commonly result in loss of the urinary bladder (detruser) reflex.

DIVISIONS AND EFFECTS OF LESIONS

Also see The Neurologic Evaluation. The PNS consists of 26 or more pairs of spinal nerves that correspond to each spinal cord segment and 12 pairs of cranial nerves that correspond to specific brain and brain-stem segments.

The PNS spinal nerves form the brachial plexus to the thoracic limb; the lumbosacral plexus to the pelvic limb; and the cauda equina to the bladder, anus, and tail. Brachial or lumbosacral plexus lesions cause paresis or paralysis of a thoracic or pelvic limb, respectively, with reduced or absent spinal reflexes and reduced or absent sensation of the limb. (Also see Limb Paralysis.) Cauda equina lesions result in an atonic bladder; a dilated, unresponsive anus; and a flaccid, paralyzed tail.

Lesions of all spinal nerves (eg, acute polyradiculoneuritis) result in paresis or paralysis of all four limbs (quadriparesis or quadriplegia, respectively) with depressed or absent spinal reflexes and altered sensation of the limbs. Lesions restricted to PNS cranial nerves result in deficits associated with dysfunction of that particular nerve and no signs of dysfunction in the limbs or other parts of the nervous system.

The spinal cord of dogs and cats is divided into 8 cervical, 13 thoracic, 7 lumbar, 3 sacral, and 5 or more caudal segments. Horses and cows have 6 lumbar and 5 sacral segments, and pigs have 6–7 lumbar and 4 sacral segments. Spinal cord lesions from L4 to S2 cause pelvic limb ataxia, conscious proprioceptive deficits, and paresis or paralysis with depressed or absent spinal reflexes and muscle tone (LMN signs). Sensation may also be depressed or absent below the lesion. Lesions from T3 to L3 cause pelvic limb ataxia, conscious proprioceptive deficits, and paresis and paralysis with normal or exaggerated spinal reflexes (UMN signs). Pelvic limb sensation caudal to the lesion may also be depressed or absent. With spinal cord lesions extending from C6 to T2, thoracic limb spinal reflexes may be depressed or absent, and severe lesions may cause quadriplegia. The spinal reflexes remain intact in the pelvic limbs, but sensation may be affected.

Spinal cord lesions from C1 to C5 cause hemiparesis or hemiplegia (paresis or paralysis of the limbs on one side), or quadriparesis. Spinal reflexes in all four limbs are often preserved. Severe lesions may cause respiratory distress or arrest due to involvement of the UMNs to respiratory muscles in the C5 area.

The brain stem is divided from caudal to rostral into four segments: the medulla oblongata (myelencephalon), the pons (metencephalon), the midbrain (mesencephalon), and the thalamus and hypothalamus (diencephalon).

Similar to lesions of the cervical spinal cord, lesions of the medulla oblongata cause conscious proprioceptive deficits and weakness on the same side (ipsilateral) or both sides with normal or hyperactive limb reflexes. However, involvement of CN nuclei IX, X, XI, or XII localizes the lesion to the caudal medulla oblongata. Involvement of CN nuclei VI, VII, or VIII localizes the lesion to the rostral medulla oblongata. It is rare to have a lesion of the medulla oblongata that does not affect one or more of the cranial nerves as well as sensory and motor tracts.

Pontine lesions cause ipsilateral conscious proprioceptive deficits, hemiparesis or quadriparesis with normal or hyperactive limb reflexes, mental depression from involvement of the ascending reticular activating system (ARAS), and CN V and IV deficits.

The cerebellum is part of the metencephalon and is attached to the dorsal surface of the pons and medulla by rostral, middle, and caudal cerebellar peduncles. The cerebellum coordinates all muscle activity and establishes muscle tone. The flocculonodular lobe of the cerebellum has equilibrium functions and is considered part of the vestibular system. Unilateral lesions of the cerebellum cause ipsilateral dysmetria (hypermetria or hypometria) and a contralateral (paradoxical) head tilt. Bilateral lesions of the cerebellum cause generalized incoordination of the head and limbs, head tremors (intention tremors), and generalized dysequilibrium.

Midbrain (mesencephalon) lesions cause contralateral conscious proprioceptive deficits and hemiparesis. CN III nucleus involvement is present on the ipsilateral side and localizes the lesion to the midbrain. In large, midbrain lesions, the ARAS is affected, and the animal will be stuporous or comatose. If the sympathetic UMNs and parasympathetic LMNs are both affected in the midbrain, the pupils will be midrange size and unresponsive to light.

Diencephalic lesions can be difficult to differentiate from cerebral cortical lesions, because many tracts going to and from the cerebrum pass through the diencephalon by way of the internal capsule. The thalamus, hypothalamus, and subthalamus of the diencephalon have many important structures that alter feeding, drinking, breeding, sleeping, and other behaviors, as well as regulate body temperature. The pituitary gland, which controls many hormonal functions of the body, is connected to the hypothalamus. The ARAS projects through the subthalamus area, in which lesions also produce stupor or coma.

The telencephalon, also called the cerebral cortex, is divided into the neocortex, paleocortex, and archicortex. The paleocortex and archicortex include the olfactory and limbic regions, which provide smell and emotional reactions to all stimuli. The neocortex is divided into the frontal, parietal, occipital, and temporal lobes. The frontal cortex functions include intelligence and fine motor skills (corticospinal tract). Lesions in this area cause dementia, lack of recognition of the owner, difficulty in training, compulsive pacing, circling toward the side of the lesion (adversion syndrome), and motor seizures with contralateral involuntary muscle twitching. Contralateral hopping and placing deficits are also found with frontal lobe lesions. Ascending and descending tracts to and from the frontal lobe form the internal capsule through the region of the basal nuclei and diencephalon. Lesions of the internal capsule can produce the same signs as frontal lobe lesions. The parietal lobe (somesthetic cortex) is for interpretation of general perception, nociception, temperature, and pressure; lesions result in proprioceptive deficits on the contralateral side of the body.

Occipital lobe and optic radiation lesions result in blindness with pupils that respond normally to light. Unilateral occipital lobe and optic radiation lesions result in some degree of visual loss in the contralateral eye, depending on the percentage of crossover of the optic nerve fibers in the optic chiasm of the species (65% in cats; 75% in dogs; 80%–90% in cattle, horses, pigs, and sheep). The pupils still respond normally to light. Blindness with pupils that do not respond to light is associated with lesions of the retina, optic nerve, optic chiasm, or rostral optic tract.

Difficulty in localizing sound is hard to evaluate clinically. It may occur with temporal lobe lesions, as may psychomotor seizures characterized by hysterical running. “Fly-biting” or “star gazing” hallucinations are suspected to occur with lesions in the temporal-occipital region. Aggression occurs when the pyriform area (paleocortex) of the temporal lobe and the underlying amygdaloid nucleus are affected. Aggression can also occur with hypothalamic lesions.

Lesions of the olfactory region may alter feeding or breeding behavior. Slow-growing lesions of the cerebrum and diencephalon often result in few clinical signs because of the adaptability of functions in these areas in animals.

MECHANISMS OF DISEASE

Disease processes affecting the nervous system may be congenital or familial, infectious or inflammatory, toxic, metabolic, nutritional, traumatic, vascular, degenerative, neoplastic, or idiopathic.

Congenital disorders may be obvious at birth or shortly after (eg, an enlarged head from hydrocephalus or an uncoordinated gait from an underdeveloped cerebellum). Some familial disorders (eg, lysosomal storage diseases) cause a progressive degeneration of neurons in the first year of life, whereas others (eg, inherited epilepsy) may not manifest for 2–3 yr. (Also see Congenital and Inherited Anomalies of the Nervous System.)

Infections of the nervous system are due to specific viruses, fungi, protozoa, bacteria, rickettsia, prions, and algae. Noninfectious inflammations such as steroid-responsive meningoencephalomyelitis and meningoencephalomyelitis of unknown etiology (MUE), formerly called granulomatous meningoencephalomyelitis, Pug dog encephalitis, and other CNS inflammatory diseases, may be immune-mediated. Until there is a histologic diagnosis, the term MUE is used.

Toxicity of the nervous system is most frequently caused by organophosphates (see Organophosphates (Toxicity)), pyrethrins (see Insecticides Derived from Plants (Toxicity)), carbamates (see Carbamate

Insecticides (Toxicity)), bromethalin (see Bromethalin), metaldehyde (see Metaldehyde Poisoning), ethylene glycol (see Ethylene Glycol Toxicity), metronidazole (see Nitroimidazoles), theobromines (see Chocolate), sedatives, and anticonvulsants (eg, phenobarbital, bromide). Botulinum, tetanus, and tick toxins, as well as coral and certain other snake venom intoxications, cause neurologic signs.

Metabolic alterations of nervous system function most commonly result from hypoglycemia, hypoxia or anoxia, hepatic dysfunction, hypocalcemia, hypomagnesemia, hypernatremia, hypokalemia, and uremia. Hypothyroidism, hyperthyroidism, hypoadrenocorticism, and hyperadrenocorticism are endocrine disorders that can cause neurologic dysfunction.

Thiamine deficiency results in ataxia, stupor, and coma or seizures in dogs, cats, and cattle. Deficiency of vitamin B_6 may cause seizures.

Trauma to the PNS and CNS causes focal and multifocal neurologic signs from physical damage, hemorrhage, edema, and progressive formation of oxygen-containing free radicals and nervous system destruction that is usually complete in 24–48 hr but lasts as long as 4 days because of the slow influx of inflammatory cells..

Vascular lesions of animals are usually due to septicemia and bacterial embolization of the CNS. Fibrocartilaginous embolization of the spinal cord is common in dogs. Arteriovenous malformations occur occasionally and cause spontaneous hemorrhages. Cerebrovascular disease from arteriosclerosis is rare in domestic animals but has been associated with hypothyroidism caused by hyperlipidemia. Cerebrovascular disease from hypertension is rare but may be seen as multiple cerebral microbleeds with MRI.

Familial degeneration of neurons occurs in lysosomal storage disorders. Degeneration of intervertebral discs that subsequently herniate into the vertebral canal often produces paresis and paralysis in dogs.

Neoplasms of the CNS and PNS are most common in dogs and cats. Astrocytes, oligodendrocytes, and microglia can all become neoplastic and form astrocytomas, oligodendrogliomas, and gliomas. Ependymal cells and the choroid plexus, which line the internal cavities of the CNS and produce CSF, also can become neoplastic and form ependymomas and choroid plexus papillomas. Meningeal cells of the dura, arachnoid, and pial membranes form meningiomas, which are common in dogs and cats. Neurofibrosarcomas are common tumors of the nerve sheaths of peripheral nerves in dogs. Lymphosarcoma is a common metastatic tumor of the PNS and CNS in dogs, cats, and cattle. Hemangiosarcoma is the most common metastatic tumor of the CNS in dogs. (Also see Neoplasia of the Nervous System.)

The idiopathic mechanism of disease is reserved for described syndromes with characteristic clinical signs, predictable outcomes, and no known necropsy findings

http://www.merckvetmanual.com/mvm/nervous_system/nervous_system_introduction/overview_of_the_nervous_system.html

26. How do the nerves exit the spinal cord?

Structure and Function of the Brain and Spinal Cord in Dogs Read more at:

Where Are the Brain and Spinal Cord Located in Dogs?
The brain is located within the bony cranium or the skull. The spinal cord is located within the spinal canal that runs through the vertebral column (neck and back bone), and extends from the base of the skull down the middle of the tail. What Is the General Structure of the Brain and Spinal Cord?
The brain is a mass of soft, pinkish gray nerve tissue divided into three major compartments: the brain stem, cerebrum and cerebellum.
Brain stem. The brain stem is located at the base of the brain and is connected to the spinal cord and cerebellum. Almost all of the cranial nerves (nerves that control various functions on the head) arise from the brain stem.
Cerebrum. The cerebrum, which forms the bulk of the brain, may be divided into two major parts: the right and left cerebral hemispheres. The hemispheres are divided by a narrow slit or cleft called the cerebral longitudinal fissure. The two sides of the brain are connected at the bottom by the corpus callosum, which delivers messages from one side to the other.
Cerebellum. The cerebellum is located at the back of the brain and is attached to the brain stem and cerebrum. The cerebellum functions chiefly to coordinate movement and posture. The spinal cord is an elongated structure, more or less cylindrical, that is made up of the major bundle of nerve tracts that carry nerve impulses to and from the brain to the rest of the body. The spinal cord is connected to all areas of the body by nerves that leave and enter the spinal column through the gaps between the bony vertebrae. Both the brain and the spinal cord are enclosed within the meninges, which consists of three tough membranes called the dura mater, arachnoid and pia mater. Cerebrospinal fluid (CSF) is produced within the brain in hollow channels called ventricles. This fluid surrounds the brain and spinal cord to protect them from injury. Both brain and spinal tissue can be subdivided into gray matter and white matter.
What Are the Functions of the Brain and Spinal Cord for Dogs?
The brain governs various behaviors through learning, motivation and perception. It produces nerve impulses to make muscles move, to send signals to organs, and to control numerous automatic bodily functions. The brain also receives and registers sensory impulses, such as sight, sound, taste, touch, smell, and pain. The spinal cord acts to coordinate movement and muscular activity. It also governs both automatic and voluntary reflexes, such as blinking, scratching, twitching the ears, and wagging the tail. Read more at: http://tr.im/thWBv

http://www.petplace.com/article/dogs/diseases-conditions-of-dogs/body-structure-function/structure-and-function-of-the-brain-and-spinal-cord-in-dogs

27. Describe the dorsal and ventral root.

CHAPTER 17

Spinal Nerves

The **spinal nerves** (*nervi spinales*) (Figs. 17-1 and 17-2) usually number 36 pairs in the dog. Each spinal nerve consists of four segments from proximal to distal: (1) roots, (2) main trunk, (3) four primary branches, and (4) numerous peripheral branches (Fig. 17-3*A*). The roots lie within the vertebral canal and consist of a **dorsal root** (*radix dorsalis*) with a **spinal ganglion** (*ganglion spinale*), and a **ventral root** (*radix ventralis*). Each root is formed by a variable number of rootlets (*fila radicularia*) that attach to the spinal cord. Union of the dorsal and ventral roots forms the main trunk of the spinal nerve, which is located largely within the intervertebral foramen. Within the intervertebral foramen, the spinal nerve gives off a small and variable **meningeal branch** (*ramus meningeus*). After emerging from the intervertebral foramen, the spinal nerve gives off a **dorsal branch** (*ramus dorsalis*), then a **communicating branch** (*ramus communicans*), and continues as a larger **ventral branch** (*ramus ventralis*). The dorsal and ventral branches usually subdivide into medial and lateral branches, which give rise to numerous smaller branches.

The dorsal and ventral roots are found within the vertebral canal; the spinal ganglion, formerly the *dorsal root ganglion*, is located in the dorsal root at the junction of the dorsal and ventral roots, near the intervertebral foramen. Each dorsal and ventral root consists of a varying number of rootlets, or **root filaments** (*fila radicularia*) (Fig. 17-3*B*). The dorsal rootlets send axons into the spinal cord at the dorsolateral sulcus. The ventral rootlets emerge from the spinal cord at a wide, indistinct, ventrolateral sulcus. Neither the dorsal nor the ventral roots are compact units. They consist of loosely united bundles of axons, root filaments, that are difficult to differentiate from each other because of the transparency of the covering arachnoid membrane that collapses on them after death. The number of dorsal root filaments agrees closely with the number of ventral root filaments for each spinal nerve. The number of dorsal and ventral root filaments averages six each for the first five cervical nerves. They increase in size and in number to an average of seven dorsal and seven ventral filaments from the fifth cervical segment as far caudad as the second thoracic segment. From the second thoracic segment through the thirteenth thoracic segment there are two dorsal and two ventral filaments that form each thoracic nerve root.

Each dorsal and ventral root is surrounded near the spinal cord by pia and arachnoid trabeculae and then by cerebrospinal fluid in the subarachnoid space. This segment of a nerve root is often referred to as the *intradural segment*. More distally, a nerve root enters a meningeal tube formed by the arachnoid membrane and the dura mater (Fig. 16-4). This segment of a spinal nerve in a meningeal tube has been referred to as the *extradural segment* of a spinal nerve root. This is a misleading term because the meningeal tube consists of three layers of meninges, including a small subarachnoid space containing cerebrospinal fluid. If a term is warranted for this section of the roots, the tubular portion describes that component of the roots that is enveloped by all three meningeal layers. At the spinal ganglion, the meninges continue on the main trunk of the spinal nerve and its branches as the epineurium.

Because the vertebral column and the spinal cord continue to grow after birth at different rates (Chapter 16), the total length of the spinal cord is less than the length of the vertebral canal; thus the last several lumbar, the sacral, and the caudal nerves have to run increasingly longer distances before they reach the corresponding intervertebral foramina to exit from the vertebral canal. These roots have much longer intradural as well as tubular segments than do the more cranial roots (Figs. 16-4 and 16-5). Because the caudal part of the spinal cord (S-1 caudally) and the nerves that leave it resemble a horse's tail, this part of the spinal cord (the conus medullaris), with the spinal roots coming from it, is called the *cauda equina* (see Chapter 16). The cauda equina is therefore a part of the peripheral nervous system.

The **spinal ganglia** (*ganglia spinalia*), formerly referred to as *dorsal root ganglia*, are aggregations of pseudounipolar nerve cell bodies that are located in the dorsal root within (rarely external to) the corresponding intervertebral foramen. The axons of the pseudounipolar cells divide into central and peripheral processes. The central processes form the dorsal root filaments, whereas the peripheral processes intermingle with the axons of the ventral root filaments in forming the main trunk of a spinal nerve that thus contains both sensory (afferent) and motor (efferent) fibers, commonly referred to as a *mixed* nerve.

INITIAL OR PRIMARY BRANCHES OF A TYPICAL SPINAL NERVE

Each spinal nerve usually has three or four primary branches arising from the main trunk. Just peripheral to the spinal ganglion, a variable **meningeal branch** (*ramus meningeus*) may arise from the main trunk and turn back into the vertebral canal. The meningeal branch consists of afferent (sensory) axons and postganglionic sympathetic axons that supply the dura mater, the dorsal longitudinal ligament, the ventral internal vertebral venous plexus, and other blood vessels located in the vertebral canal (Pederson et al., 1956). The meningeal branch in the dog is microscopic in size (Forsythe & Ghoshal, 1984). They also report that each annulus fibrosus of the intervertebral disk is supplied by meningeal branches from two or more spinal nerves.

The **dorsal branch** (*ramus dorsalis*) of a spinal nerve extends dorsad and usually divides into medial and lateral branches to

Another partition, the *diaphragma sellae,* separates brain from the hypophysis and the cavernous venous sinuses. It is penetrated by the infundibulum of the hypophysis and by internal carotid arteries.

Leptomeninges

Arachnoid membrane and pia mater, separated by a subarachnoid space but connected by arachnoid trabeculae, constitute the leptomeninges. Embryologically, the arachnoid membrane and pia mater are derived from a common mesenchyme layer predominantly of neural crest origin, that undergoes cavitation to form the subarachnoid space.

Arachnoid membrane (*arachnoidea encephali, arachnoidea spinalis*) is composed of flattened fibroblasts associated with a fine net of collagen fibers. *Arachnoid trabeculae,* which connect arachnoid membrane to pia mater, are formed by thin strands of collagen fibers coated by flattened fibroblasts.

Pia mater consists of collagen fibers and superficial, flattened fibroblasts (Allen & Low, 1975). Flattened leptomeningeal fibroblasts thus line the entire subarachnoid space (fenestrations may occur in the cellular lining). The collagen fibers of pia mater make contact with a basal lamina on the nervous tissue surface (astrocyte processes of a glial limiting membrane contact the deep surface of the basal lamina). Because it is intimately attached to the surface of the central nervous system, the pia mater extends into the depths of various sulci, fissures, and crevices of the central nervous system.

The depth of the **subarachnoid space** (*cavum subarachnoideale*) is variable, because arachnoid membrane contacts dura mater and the pia mater follows every irregularity of the brain surface. At certain sites, crevices of the brain surface establish subarachnoid space enlargements known as *cisternae.* Most important is the *cisterna cerebellomedullaris,* formerly *cisterna magna,* which is located where the caudal surface of the cerebellum meets the dorsal surface of the medulla oblongata (Fig. 16-15). It is the largest cisterna and the most common site for obtaining cerebrospinal fluid (de Lahunta, 1983).

Pia mater collagen is bilaterally thickened along the lateral surface of the spinal cord, forming a **denticulate ligament** (*ligamentum denticulatum*) (Figs. 16-3 and 16-5). Denticulate ligaments have lateral extensions that traverse the subarachnoid space and attach to dura mater, thereby suspending the spinal cord in cerebrospinal fluid within the subarachnoid space. Caudally, each denticulate ligament terminates in a process that connects to the dura mater between the entrances of the L5 and L6 spinal roots into dural sheaths; in 25% of dogs, the termination is between the L6 and L7 roots (Fletcher & Kitchell, 1966a).

The pia mater is relatively vascular, because all vessels entering and leaving the central nervous system must travel in pia mater. Vessels passing through the subarachnoid space are covered by leptomeningeal fibroblasts, derived from arachnoid trabeculae. Large vessels penetrating central nervous system tissue are surrounded for a short distance by an apparent perivascular extension of the subarachnoid space, although communication between subarachnoid and perivascular spaces may be sealed by merger of the leptomeningeal fibroblast layer covering vessels with that on the pia mater surface (Krahn, 1982).

As a vessel proceeds and divides into smaller branches within the central nervous system, the size of its perivascular space is progressively reduced. Ultimately, capillaries are surrounded only by basal laminae, the outer surface of which is contacted by astrocyte end feet. (Endothelial cells of the central nervous system capillaries lack fenestrations and are united by zonulae occludentes, which is the explanation for the blood-brain barrier to diffusion of hydrophilic molecules.)

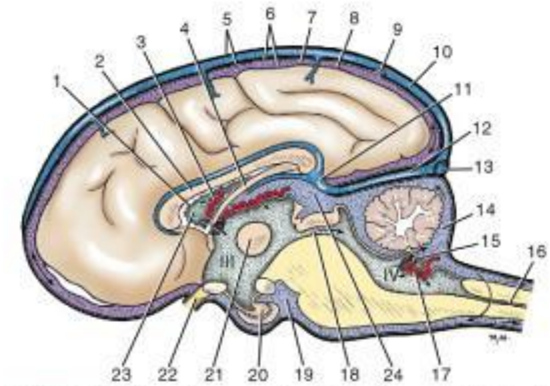


FIGURE 16-15 Schema of meninges and ventricles. *Arrows* indicate the flow of cerebrospinal fluid. (From Evans HE, de Lahunta A: *Miller's guide to the dissection of the dog,* Philadelphia, 1974, WB Saunders.)

1. Cut edge of septum pellucidum
2. Corpus callosum
3. Choroid plexus in lateral ventricle
4. Fornix of hippocampus
5. Dura mater
6. Arachnoid membrane and trabeculae
7. Subarachnoid space
8. Pia mater
9. Arachnoid villus
10. Dorsal sagittal sinus
11. Great cerebral vein
12. Straight sinus
13. Transverse sinus
14. Cerebellomedullary cistern
15. Lateral aperture of fourth ventricle
16. Central canal
17. Choroid plexus
18. Mesencephalic aqueduct
19. Intercrural cistern
20. Hypophysis
21. Interthalamic adhesion
22. Optic nerve
23. Lateral ventricle
24. Quadrigeminal cistern

The Ventricular System

The lumen of the embryonic neural tube persists as the ventricular system of the brain and the central canal of the spinal cord. These cavities are lined by ependymal epithelium and are filled with cerebrospinal fluid. The chambers of the ventricular system communicate with one another, with the central canal, and with the subarachnoid space (Fig. 16-16).

The brain has one **lateral ventricle** (*ventriculus lateralis*) within each cerebral hemisphere. Through an interventricular foramen, each lateral ventricle communicates with the **third ventricle** (*ventriculus tertius*), a narrow, median plane chamber surrounding the interthalamic adhesion of the diencephalon. The **mesencephalic aqueduct** (*aqueductus mesencephali*) of the midbrain is a canal that connects the third and fourth ventricles. The **fourth ventricle** (*ventriculus quartus*) is located in the hindbrain. It communicates with the central canal and, by means of paired lateral recesses and apertures, with the subarachnoid space (see Fig. 16-16).

At one region along the wall of each ventricle, nervous tissue is absent so that pia mater contacts ependyma. The combined tissue, called *tela choroidea,* forms part of the floor of each lateral ventricle and the roof of the third and fourth ventricles. Tela choroidea plus a plexus of capillaries gives rise to *choroid plexus.* Each choroid plexus projects into a ventricle as a band of clustered villi. The linear attachment of tela choroidea to the adjacent brain parenchyma is designated *taenia* epaxial muscles and the skin near the dorsal midline (Fig. 17-4).

The **ventral branch** (*ramus ventralis*) is the largest of the four primary branches. It divides into medial and lateral branches except where the ventral branches form the large brachial and lumbosacral plexuses or supply the tail. The medial and lateral branches supply hypaxial muscles of the body wall and give off lateral and ventral cutaneous branches that supply the skin of the lateral and ventral aspects of the body wall.

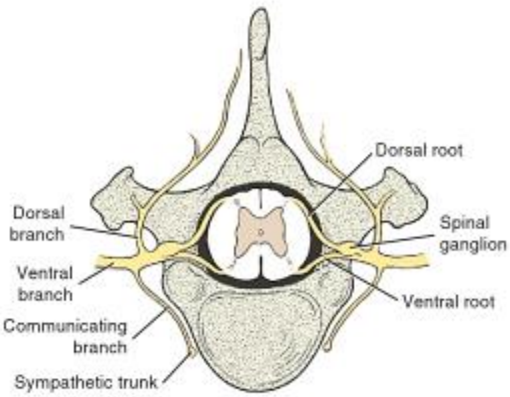


FIGURE 17-1 Diagram of a spinal nerve.

The **communicating branch** (rami communicantes), also called the *visceral branch*, differs from the dorsal and ventral branches in that it carries no somatic afferent or somatic efferent axons. It carries only general visceral afferent and efferent axons to and from visceral structures (gland tissue and smooth muscle). The efferent axons are preganglionic sympathetic axons.

The spinal nerves usually leave the vertebral canal through spaces between adjacent vertebrae, the **intervertebral foramina**. The number of vertebrae and the number of spinal nerves for each vertebral region are not always the same. There are eight pairs of cervical nerves, but only seven cervical vertebrae. In most dogs, there are 20 caudal vertebrae, but only the first five pairs of caudal nerves usually develop.

The three sacral vertebrae are fused to form the sacrum, and there are two dorsal and two ventral pairs of sacral foramina for the passage of the dorsal and ventral branches of the first two pairs of sacral nerves. The third pair of sacral nerves pass through intervertebral foramina located between the sacrum and the first caudal vertebra.

GENERAL FEATURES OF SPINAL NERVES

Functionally, peripheral branches of the dorsal and ventral primary branches of spinal nerves can be classified as sensory nerves with axons from the skin (cutaneous branches) or deeper, nonmuscular structures; motor nerves with efferent axons to muscle and afferent axons from receptors in muscle; or mixed, giving off both sensory and motor branches.

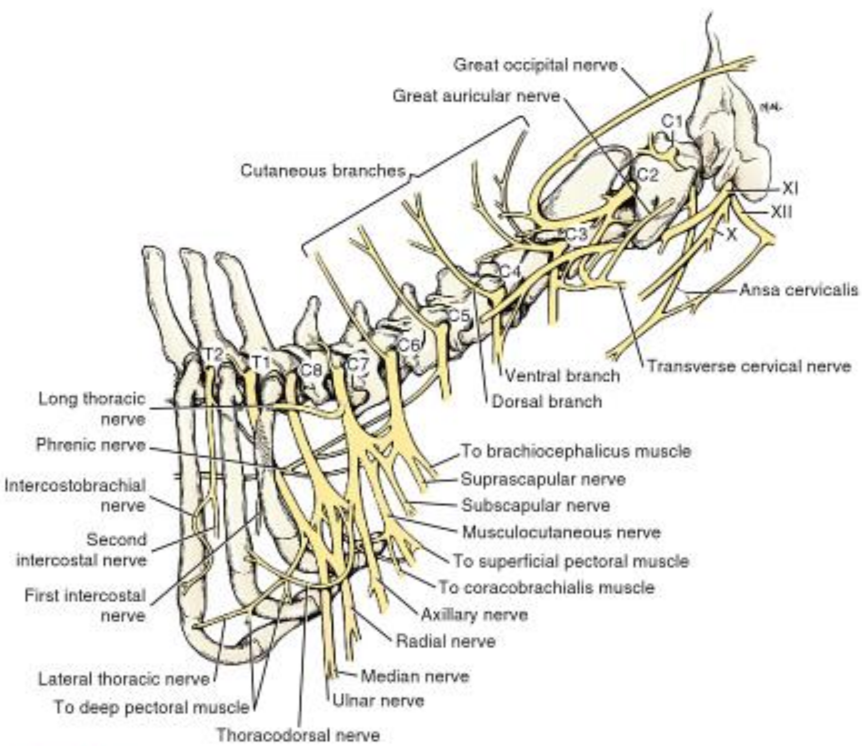


FIGURE 17-2 Schema of the cervical nerves and brachial plexus. The numbers C-1 through C-8 and T-1 and T-2 refer to spinal nerves, not vertebrae.

28. What is the efferent and afferent?

Efferent Neurons

Efferent Neurons (also known as efferent nerve fibers) are conducting cells that carry information from the central nervous system (the brain and spinal cord) to muscles and organs throughout the body. These neurons carry electrical impulses that tell organs and muscles what to do. To move your arm efferent neurons would carry the electrical impulse from your brain, throughout the spinal cord and to your arm where muscles receive the information to move. The opposite of efferent neurons are afferent neurons which carry impulses from receptors in muscles, organs, and glands to the central nervous system.

Read more: http://www.alleydog.com/glossary/definition.php?term=Efferent%20Neurons#ixzz3kLh0rPg4

29. Name and describe the Radial Nerve, Median Nerve, Ulnar Nerve, Femoral Nerve, Sciatic Nerve, Tibial Nerve.

Radius

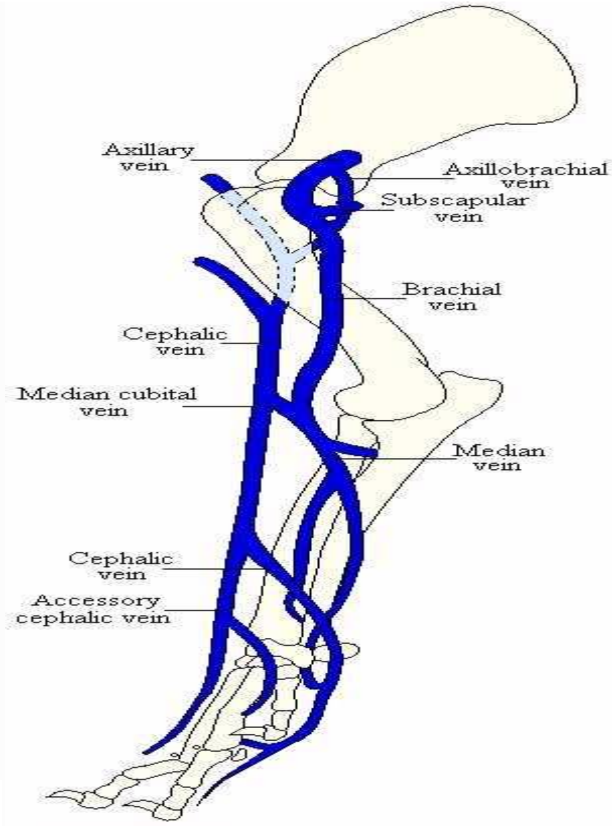
While in the human the radius and ulna are separated by an interosseus space and articulate only at their extremities, allowing for significant capability of supination and pronation, these movements are much more limited in domestic animals due to the gradual fusing of the two bones. The extreme case is exhibited by the horse.

The radius forms the shaft-like rod of the distal limb, which is bowed to varying degrees amongst species. It articulates proximally with the distal humerus, caudally with the ulna, and distally with the carpus. Medially on the distal articular process, a styloid process projects, which is mirrored laterally by the ulna.

Ulna

The Ulna's greatest contribution to functional anatomy is in the formation of the olecranon, or the point of the elbow, which gives rise to the attachment of the triceps muscle. The olecranon articulates with the humerus via its anconeal process. The olecranon develops as an apophysis, i.e.. from a separate site of ossification. The trochlear notch on the cranial aspect of the ulna articulates with the large trochlea of the humerus which forms the main elbow joint capable of flexion and extension. Just distal to the trochlear notch, a large medial coronoid process and a smaller lateral coronoid process can be seen. Distally (where unfused), the lateral styloid process articulates with the ulnar carpal bone.

https://en.wikivet.net/Forelimb_-_Anatomy_%26_Physiology#Radius



http://d-mis-web.ana.bris.ac.uk/calnet/LFvasc/image/venous%20drainage%20of%20right%20forelimb-medial%20view.jpg

Common Structures of the Distal Forelimb

Radius

While in the human the radius and ulna are separated by an interosseus space and articulate only at their extremities, allowing for significant capability of supination and pronation, these movements are much more limited in domestic animals due to the gradual fusing of the two bones. The extreme case is exhibited by the horse.

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Carpal bones

Carpal bones comprise two rows:

- Proximally, (mediolaterally), radial, intermediate, ulnar and accessory bones. The accessory bone serves as a landmark for palpation.
- Distally, bones are numbered 1-5, though 5 is always fused with 4.

A small sesamoid bone embedded in the medial tissues of the joint can sometimes be mistaken as a chip fracture.

Metacarpal bones

The number of metacarpals varies widely among species, as the demand for their function changes: plantigrade, or flat-footed, animals requiring the full complement of five metacarpal bones; the number is reduced in the upright stature of digitigrade animals such as the dog and cat, and shows the extreme in unguligrades like the horse, which depends entirely on the third metacarpal bone for its stature.

Colloquially, the third metacarpal of the horse is known as the canon bone, and the vestigial 2 and 4 as splint bones

https://en.wikivet.net/Forelimb_-_Anatomy_%26_Physiology

The femoral nerve arises from L4-L6 vertebrae, and the sciatic nerve arises from L6-S2 vertebrae. In general, the femoral nerve provides innervation to the medial aspect of the hindlimb distally to just below the stifle. The sciatic nerve, along with its branches, provides innervation to the remainder of the hindlimb (Figure 1).

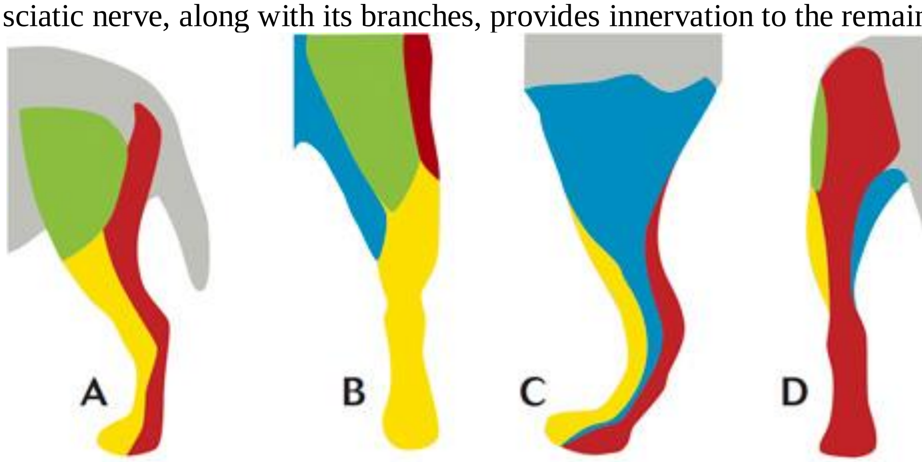


Figure 1: Innervation to the hindlimb. Blue represents the area that the femoral nerve innervates, maroon represents the caudal cutaneous nerve (seen in B), yellow represents the peroneus nerve and red represents the tibial nerve. The last three nerves are blocked with the sciatic nerve block. The green area is supplied by the lateral femorocutaneous nerve. (Illustration by Steph Bentz, adapted from image courtesy of Diego A. Portela, MV, PhD)
http://veterinarynews.dvm360.com/performing-femoral-and-sciatic-nerve-blocks

30. Where do they exit the body and what animal moves directly touch these exits?

The bowen moves that directly touch these areas are: 4, 9,11,15,16,17,18 and 19.

31. What is a plexus? A nerve plexus is a network of intersecting nerves; multiple nerve plexuses exist in the body. Examples include: the cervical, brachial, lumbar, sacral, celiac, and coccygeal plexuses. https://www.google.ca

32. What are the different names of theses plexus and where are they located?

The brachial plexus is a collection of nerve tissue arising from the spinal cord, which gives rise to the individual nerves that supply the forelimbs. Avulsion of the brachial plexus refers to stretching and tearing of this nerve tissue. The nerves are usually torn from their root of attachment to the spinal cord. The most common cause of brachial plexus avulsion is vehicular trauma, but any type of trauma that results in significant traction on the forelimb, resulting in overstretching of the armpit/shoulder area, may result in brachial plexus avulsion. The avulsion results in severe weakness or paralysis of the affected forelimb.

Injury to the **brachial plexus** or the C6 to T2 nerve roots is common in most species due to direct shoulder trauma or abnormal shoulder abduction (eg, in small animals hit by automobiles). Horses and cattle cast on hard surfaces for foot or other surgeries may develop a brachial plexus injury. If Horner syndrome is present on the same side as a thoracic limb that has lost sensation and is areflexic and paralyzed, a brachial plexus avulsion is likely, and the prognosis for recovery grave. With brachial plexus avulsion, the nerve roots are torn from the spinal cord and cannot be repaired. If there is also no response to radial nerve stimulation, recovery is hopeless. If the limb drags on the ground, it can be held up with a neck sling or amputated in small animals to avoid laceration of the dorsal surface of the paw. Three-legged dogs and cats generally have a good quality of life. If no Horner syndrome is present with thoracic limb paralysis, the prognosis for recovery may be better.

Lumbosacral plexus injuries are less common than brachial plexus injuries but can be associated with automobile accidents or extreme limb abduction. Fractures of long bones can injure peripheral nerves locally. Surgical intervention for pelvic and hip disease and injection injuries are common causes of sciatic nerve injuries. Sustained pressure on the lateral aspect of the stifle can cause peroneal nerve injury. Heat application, massage, and stretching of tendons should be performed for 15 min 2–3 times/day to keep muscles, tendons, and joints healthy while the nerve is regenerating. A light bandage may prevent damage to the foot from dragging, but reduction of circulation should be avoided. No specific therapy is currently available to assist nerve regeneration, but recent studies with laser therapy, also known as cold laser, low level light therapy, or photobiomodulation, has shown some promise in assisting nerve regrowth. In traumatic injuries with accompanying swelling, small animals may be given NSAIDs or a short course of anti-inflammatory oral prednisone at 0.5 mg/kg/day for 5–7 days. This will help reduce edema, which can compromise circulation to the nerve. NSAIDs and corticosteroids should not be used concurrently. NSAIDs can be given to horses to reduce edema. If voluntary movement, nociception, and spinal reflexes improve within 1–2 mo, the prognosis is good. Limb mutilation can be transient in recovering nerve injuries and may be prevented by temporary use of an elizabethan collar. If nerve injury is suspected to be permanent and the animal is mutilating the limb, amputation is recommended in small animals. Enough time should be allowed to pass for possible regeneration of the nerve, typically 3–6 mo, before amputation.

Neoplasia of nerve roots and peripheral nerves can cause a chronic, progressive, often painful paresis of a thoracic or pelvic limb (See also Neoplasia of the Peripheral Nerve and Neuromuscular Junction and see Neoplasia of the Nervous System.). Nerve sheath tumors are common in dogs. Lymphosarcoma of the brachial or lumbosacral plexus is seen in dogs, cattle, and cats. If the nerve roots within the spinal canal are affected, an extramedullary mass may be visualized with a myelogram, CT, or MRI in dogs and cats. Surgical exploration and removal or biopsy are essential to determine diagnosis or prognosis. The longterm prognosis for nerve sheath tumors is poor, even after attempted surgical removal and limb amputation. Nerve sheath tumors often affect multiple nerve roots, and the tumor is difficult to completely remove. If appropriate chemotherapy is instituted for lymphosarcoma, the length and quality of life may be improved. Chemotherapy is not very helpful to treat nerve sheath tumors, but radiation therapy may have some benefit.

Horses with equine protozoal myeloencephalitis (EPM, see Equine Protozoal Myeloencephalitis) may develop monoparesis and focal muscle atrophy. CSF analysis and CSF and serum EPM titers should be evaluated so appropriate therapy can be administered.

http://www.merckvetmanual.com/mvm/nervous_system/limb_paralysis/overview_of_limb_paralysis.html

33. Describe at least three disorders of the peripheral nerves.

Degenerative Diseases

Acquired laryngeal paralysis is common in middle-aged and older dogs, especially in large breeds, such as Labrador Retrievers, Golden Retrievers, and Saint Bernards. In most cases, the cause is unknown, but it can be caused by an injury or tumor affecting the neck or by thyroid disorders. Signs include voice change, noisy breathing, and a dry cough. In severe cases, the dog may have difficulty breathing, be unwilling or unable to exercise, and the tongue and gums may turn bluish. Some dogs have more general signs of a neurologic disorder, such as weakness and reduced sense of position. Although surgery cannot completely resolve the signs, it can usually relieve the breathing difficulties.

Dancing Doberman disease is a neuromuscular disorder that affects Doberman Pinschers older than 6 months. Initially, dogs repeatedly flex the hip and extend one hind leg while standing. Within several months, most dogs alternately flex and extend both hind legs in a dance-like motion. They often prefer to sit rather than stand. The condition slowly progresses to mild partial paralysis. The front legs are not affected. The cause is unknown. There is no treatment, and signs do not improve. However, this disease usually does not result in severe disability and does not appear to be painful.

Inflammatory Disorders

Acquired myasthenia gravis is a disease of the connections between the muscles and nerves. It is most common in adult German Shepherds, Golden Retrievers, and Labrador Retrievers.

Common signs are stiffness (brought on by exercise), tremors, and weakness that improve with rest. Weakness of the face and throat muscles is common, and often there is difficulty swallowing or regurgitation of food after eating. Pneumonia is a frequent complication. Diagnosis requires a blood test. Medications are available for long-term treatment. The outlook for recovery is generally good, but less so for animals that suffer complications.

Acute idiopathic polyradiculoneuritis causes inflammation of peripheral nerves. Signs often develop 7 to 14 days after a raccoon bite or scratch (leading to the name of Coonhound paralysis); however, not all affected animals have been exposed to raccoons. A similar syndrome can develop in dogs within 1 to 2 weeks of a vaccination. Typically, the hind legs become weak and within 24 to 48 hours the signs progress to partial paralysis in all legs and, in some cases, weakness in the face and throat. Occasionally, the front legs are affected first. Typically, muscle wasting is severe within 2 weeks. The dog does not lose its pain perception or bladder and bowel function. There is no effective treatment other than nursing care. Most affected animals begin to improve within 3 weeks, with complete recovery by 2 to 6 months. However, animals with severe signs may not recover completely, and death can occur from respiratory paralysis. Relapses are also seen, especially in hunting dogs that frequently encounter raccoons.

Trigeminal neuritis results in inflammation of and damage to the trigeminal nerve, causing a sudden onset of jaw paralysis. Affected animals cannot close the mouth and have difficulty eating and drinking. Partial paralysis and a loss of sensation in the rest of the face are also possible. The cause is unknown. Signs usually resolve within 3 to 4 weeks. Fluid and nutritional support may be necessary.

Metabolic Disorders

Hypothyroid neuropathy can be seen in dogs with a thyroid condition. Adult dogs, especially of large breeds, are at the most risk. Signs vary widely, and may include partial paralysis, weakened reflexes, loss of paw position sense in all 4 legs, loss of balance, inability to swallow, and vomiting. In most dogs, more typical signs of a thyroid condition are present, such as obesity and hair loss (see Hormonal Disorders of Dogs: Disorders of the Thyroid Gland in Dogs), but in some cases the neurologic signs are the only signs of illness. Usually, signs resolve within several months of starting thyroid replacement therapy.

Tumors

Nerve sheath tumors in dogs often arise in the peripheral nerves that extend to the front legs, initially causing weakness and pain in a leg that may be mistaken for a bone or muscle injury. A large tumor may appear as a visible lump. Partial paralysis and muscle wasting eventually develop in the affected leg. If the tumor spreads, it may eventually put pressure against the spinal cord, causing neurologic signs in other legs. Nerve sheath tumors can also form in the cranial nerves, most frequently in the trigeminal nerve. This results in muscle wasting and pain on one side of the jaw. Eventually, the brain stem can become compressed, leading to death. Surgery can be very beneficial at an early stage, but recurrence is common.

In paraneoplastic neuropathy, a cancer outside the nervous system causes damage to nerves. It is most common in dogs with insulinoma but has been associated with a variety of other tumors. This condition is not well understood, but it may be caused by an immune system response to a tumor that indirectly harms the nervous system. Signs typically involve partial paralysis in either 2 or 4 legs that progressively worsens over several weeks. Diagnosis requires identification of the underlying tumor. Signs may improve with successful treatment of the tumor.

Toxic Disorders

Organophosphate poisoning can result from exposure to pesticides, herbicides, or other industrial chemicals. The signs depend on the severity of exposure. The acute form prevents the body's acetylcholinesterase from working properly. Acetylcholinesterase is an enzyme that is essential for the proper function of connections between neurons, and between nerve and muscle. Signs of severe poisoning can include vomiting, diarrhea, salivation, shortness of breath, muscle tremors and twitching, seizure, or coma.

The intermediate form can cause generalized muscle weakness. Affected animals may not show obvious signs at first, but partial paralysis of the legs and stiffness of the neck can develop several days after exposure. The pupils may be dilated. Treatment of acute or intermediate toxicity includes the drug atropine, which blocks the effects of the organophosphate. Other medications are used to relieve the tremors and muscle weakness. Treatment for several weeks may be necessary.

In the delayed form of toxicity, the nerves slowly degenerate. This form is unrelated to the effects on acetylcholinesterase. Signs develop several weeks after exposure and typically involve weakness and loss of motor control in the hind legs. There is no specific treatment (see Poisoning: Organophosphates).

Tick paralysis (see Brain, Spinal Cord, and Nerve Disorders of Dogs: Tick Paralysis in Dogs) is caused by the bite of several species of ticks that results in rapidly progressing paralysis.
In Australia, the tick *Ixodes holocyclus* causes an especially severe form of tick paralysis. Signs begin with partial paralysis in the hind legs that worsens within 24 to 72 hours to total paralysis in all 4 legs. Sensory perception and consciousness remain normal. Difficulty swallowing, facial paralysis, jaw muscle weakness, and respiratory paralysis may develop in severe cases. Treatment consists of removing the tick and applying a skin ointment to kill any hidden ticks. For all except *Ixodes holocyclus* cases in Australia, recovery usually occurs in 1 to 2 days. A serum is available for treatment of *Ixodes holocyclus* paralysis, but death from respiratory paralysis can occur despite treatment.

Injury and Trauma

Brachial plexus avulsion occurs in dogs due to injury to the spinal nerve roots in the neck and shoulder area that extend nerves into the front legs. In a severe injury, the nerve roots may stretch or tear from their attachment to the spinal cord. Signs vary depending on the severity. If the nerves are completely torn, paralysis of the leg and a loss of sensation and reflexes below the elbow result. The animal puts little or no weight on the leg and drags the paw on the ground. The leg may need to be amputated because of damage from dragging or self-mutilation. Recovery is possible in mild cases in which the nerve roots are bruised but not completely torn.

Peripheral nerve injuries are common in traumatic injuries. The sciatic nerve, which runs from the lower back to the hind legs, may be injured by hip fractures or during surgery to correct a broken leg. Irritants injected in or near the nerve can also cause nerve damage. The leg may be partially paralyzed, or the animal may not be able to flex the knee. The paw and digits cannot flex or extend. There may be loss of sensation below the knee. Injury to the branches of the sciatic nerve in the lower leg, such as the tibial nerve or the peroneal nerve, can result in an inability to extend the paw or flex the digits and reduced sensation over the surface of the foot.

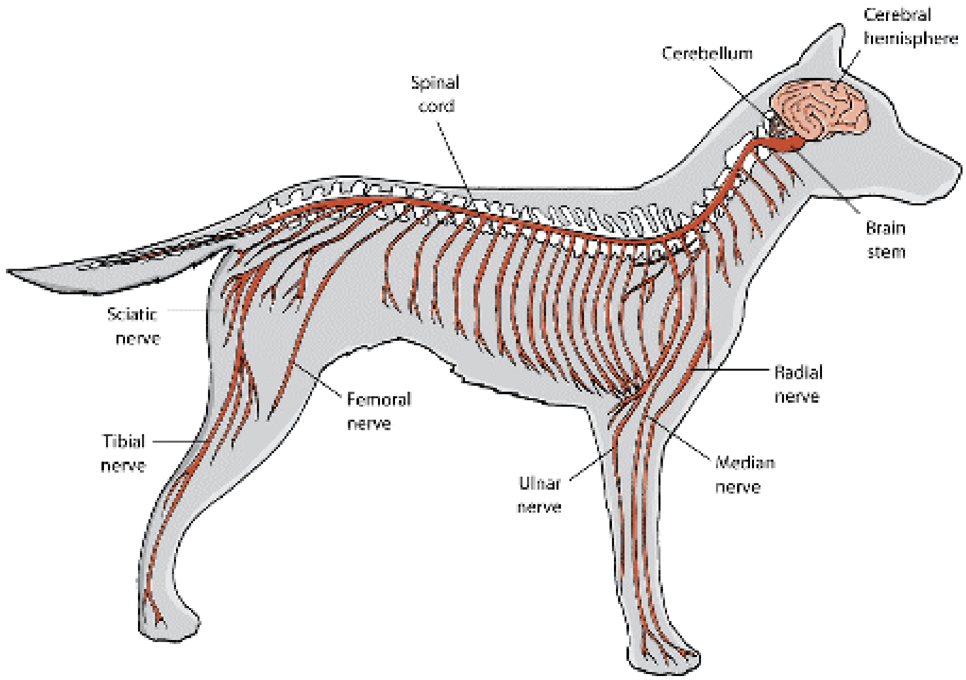
For function to return after nerve connections are lost, the nerve must regenerate from the point of injury all the way to where it ends in the muscle. Nerve tissue regenerates or heals very slowly. Recovery is unlikely if the severed ends of the nerve are widely separated or if scar tissue interferes with healing. Anti-inflammatory drugs have been used to treat traumatic nerve injuries, although there is little evidence of any benefit. Surgery should be performed promptly in cases in which the nerve has been cut. In cases of injury from a fall or a blunt object, surgical exploration and removal of scar tissue may help. Longterm care consists of physical therapy to minimize muscle wasting and to keep the joints moving. Bandages or splints may be necessary to help protect a damaged limb.

33. Describe the other 4 branches of the peripheral nerves.

The **central nervous system** includes the spinal cord and the brain. The brain is divided into 3 main sections—the **brain stem**, which controls many basic life functions, the **cerebrum**, which is the center of conscious decision-making, and the **cerebellum**, which is involved in movement and motor control. The spinal cord of dogs is divided into regions that correspond to the vertebral bodies (the bones that make up the spine) in the following order from neck to tail: cervical, thoracic, lumbar, sacral, and caudal segments. Specialized tissues called the **meninges** cover the brain and spinal cord, and cerebrospinal fluid surrounds and protects the brain and spinal cord.

The **peripheral nervous system** consists of the nerves that are found throughout the rest of the body.

The nervous system of the dog.



Neurons

Both the central and peripheral nervous systems contain billions of cells known as neurons. Neurons connect with each other to form neurological circuits. Information travels along these circuits via electrical signals.

All neurons have a center portion called a **cell body** and 2 extensions called **dendrites** and **axons**. Dendrites receive signals from other neurons and transmit electrical charges *to* the cell body. Axons transmit the electrical charges *away* from the cell body. When the current reaches the end of the axon, the axon releases chemicals called **neurotransmitters**. Neuro-transmitters pass the signal to the dendrites of other neurons, or to muscles or glands.

Neurons in the peripheral nervous system combine to form pairs of **spinal nerves** and pairs of **cranial nerves**. The spinal nerves arise from the spinal cord and extend axons outward into the front and hind legs and to the bladder, anus, and tail. These nerves subdivide into smaller nerves that cover the entire surface and interior of the body. The cranial nerves include sensory and motor neurons that connect the head and face to the brain.

Types of Neurons

Sensory neurons carry information from the body to the spinal cord or brain stem, and then on to the cerebellum and cerebrum for interpretation. Sensory information includes sensations of pain, position, touch, temperature, taste, hearing, balance, vision, and smell.

Motor neurons carry responses to the sensory information from the spinal cord and brain to the rest of the body. Inside the spinal cord, the axons of motor neurons form bundles known as **tracts**, which transmit this information to motor peripheral nerves going to muscles in the limbs. Motor neurons are important for voluntary movements and muscle control.

A specialized set of neurons controls and regulates basic, unconscious bodily functions that support life, such as the pumping of the heart and digestion. These neurons make up what is called the **autonomic nervous system**, which sends axons from the brain stem and spinal cord to various areas of the body such as the heart muscle, the digestive system, and the pupils of the eyes.

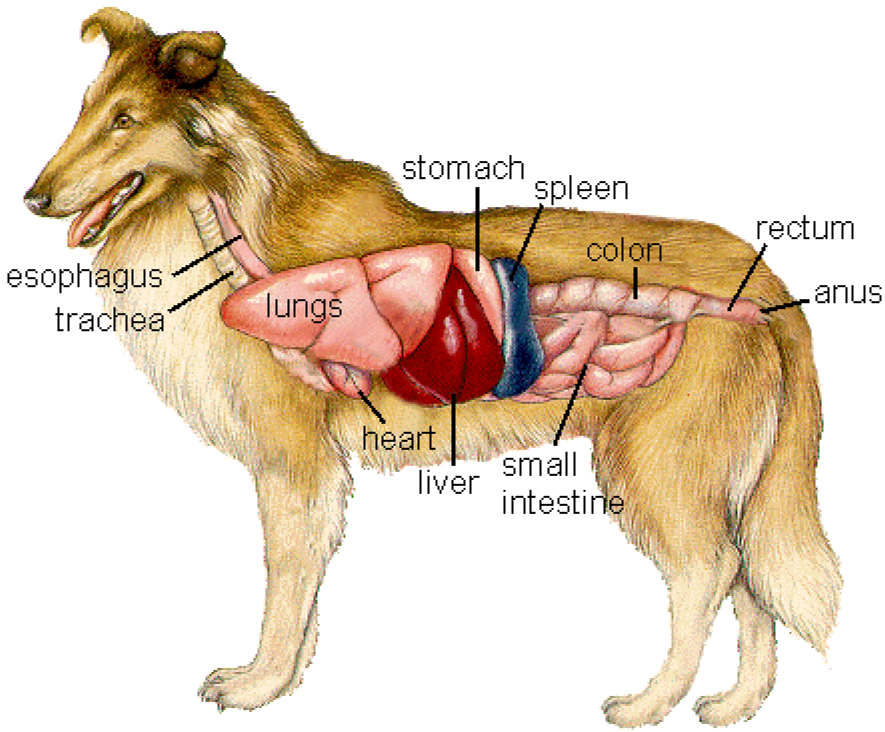
http://www.merckvetmanual.com/pethealth/dog_disorders_and_diseases/brain_spinal_cord_and_nerve_disorders_of_dogs/parts_of_the_nervous_system_in_dogs.html

35. How does Animal Bowen affect each part of the Central Nervous System?

Animal bowen affects each part of the central nervous system by touching on all major muscles and tissues while sending these signals to the brain. The signals help the brain to sort out what is new and how to help with the touch. That is why the pause is so important and the hold.

36. Give a description of each of the canine body systems i.e. respiratory, digestive, lymphatic…..

The body is composed of several functional units called organ systems. Each organ system is a collection of organs that function together to perform a specific job to keep the body healthy. Tissues, and the microscopic units of tissues, the cells, are the building blocks of organs. Tissues include materials such as muscles, nerves and epithelia and connective tissues that bind the other tissues together



* Notice that the kidneys are not labeled on this picture. The kidneys are tucked up close to the liver toward the spine.
Image modified from Hill's Pet Nutrition, Atlas of Veterinary Clinical Anatomy.

The organ systems include:

1. The cardiovascular system (cat) (dog) includes the heart and blood vessels. The cardiovascular system performs the function of pumping and carrying blood to the rest of the body. The blood contains nutrients and oxygen to provide energy to allow the cells of the body to perform work.

2. The lymphatic system includes the lymph nodes and lymph vessels. The lymphatic system is part of the immune system that helps the body fight off disease. The lymphatic system also works with the cardiovascular system to return fluids that escape from the blood vessels back into the blood stream.

3. The digestive system (cat) (dog) includes the mouth, teeth, salivary glands, esophagus, stomach, intestine, pancreas, liver and gall bladder. The digestive system absorbs and digests food and eliminates solid wastes from the body.

4. The integumentary system is the skin and fur that cover the animal's body. The skin protects the underlying organs. The fur helps insulate against heat loss. Dogs and cats do not sweat through their skin. They only sweat from their footpads and nose. They lose water by panting rather than sweating.

5. The musculoskeletal system includes all the muscles, bones and joints.

6. The respiratory system (cat) (dog) includes the mouth, nose, trachea, lungs and smaller airways (bronchi and bronchioles). The respiratory system is responsible for taking in oxygen and eliminating waste gases like carbon dioxide. Because dogs and cats do not sweat through the skin, the respiratory system also plays an important role in regulation of temperature.

7. The urogenital system (cat) (dog) includes the kidneys, ureters, urinary bladder, urethra and the genital organs of box sexes. The urinary system is responsible for removing waste products from blood and eliminating them as urine. The genital organs are involved in reproduction.

8. The nervous system includes the brain, spinal cord and all the nerves that communicate between tissues and the brain and spinal cord.

9. The endocrine system includes several glands that produce hormones. Hormones are substances that travel through the blood stream and affect other organs. Endocrine organs include the thyroid glands, parathyroid glands, adrenal glands and part of the pancreas.

10. The organs of special senses (cat) (dog) allow the animal to interact with its environment; sight, taste, smell and hearing.

11. The hematopoietic system includes the bone marrow which is located inside the bones. Three types of blood cells are made in the bone marrow: white blood cells that fight infection, red blood cells that carry oxygen and platelets that are part of the blood clotting process.

http://www.vetmed.wsu.edu/ClientED/anatomy/#Dog

37. Short Essay: Combining the answers to the above questions with your knowledge and experience with animal bowen, how can your work as an Animal Bowen Physiotherapy Practitioner directly affect the health and mobility of an animal?

As an animal Bowen practitioner we affect the body as a whole. Each move touches on a major muscle or muscle group, organ, and bones sending signals to the brain the help them out. Through this research it really opened my eyes as to how the body works as a whole to help out every system in the animal body. Just because we seem to target a section for example the hamstrings, Bowen allows other moves to touch on this area as well as surrounding areas to help the brain and body work together to improve a situation. As people our hands physically help out the situation and then the brain takes over and helps the body heel from the inside out. It is an honour to have this skill in life to help out an animal that can't tell us where is hurts. However the body gives us physical clues as to what may be the case and to me that is a starting point. If we treat the body as a whole then the moves from Bowen give us that miracle to physically see change.

Each part of the brain effects different body controls. For example the Telecephalon is the information of the senses. While the cerebrum or cerebral cortex form the bulk of the brain. The brain stem is connected to the spinal cord and the cerebellum to regulate the other signals from the body. While we are gently touching the animals with that first hug and hold we are sending messages to the brain that this area needs a bit of help or this area is where we are starting to help. After the move there is the wait and that is when the magic works because the brain is processing the signals to help the muscles move or the organs gain better function. We then see the physical results like the animal has more energy to help the rest of the body out to walk better. Maybe that limp will be less or the organs will function better even if we can't see the result there is little improvements that can be noticed. For example: I have done the kidney move on Rocky (my dog) a numerous amounts of time. After doing this I get the same results He gets relaxed, tired then the energy picks up and he eats normally again. Before the kidney procedure he doesn't eat well which is my first sign or he gets diaherra and sometimes vomiting. Then he is mope and just wants to lounge. Even though I can't physically see the improvement like a limp leg or tight hamstrings I still notice the more suttle improvements in Rocky. The kidney procedure has now become part of Rocky's maintaince plan as well as the rescue response. I keep this in mind for when I open my own Bowen clinic because not to have this help I would feel helpless for the animal as a pet owner. However through Bowen these animals now have an alternative to try and maintain a healthy lifestyle with hopes of improvement always.

Not only is the brain working to process these signals so is the nervous system. The central nervous system helps the animal carry these messages by travelling down the spinal card from the brain and out the peripheral nerves to the tissues and back again. It is like one big circle of information that continues as we send the new messages through the Bowen touch. The peripheral nervous system is important to Bowen because it is the part that sends signals from the brain to the spinal cord called the motor nerves. These motor nerves carry such information like the severity of pain to the central nervous system. By physically looking at the animal we can tell if the leg is limping. Sometimes when we touch them through the hands on assessment you can see the dogs fur flinch or they turn their head to look at you. This may be a silent way the animal saying that it hurts which comes from the central nervous system. This lets the Bowen Practitioner know what general area to start with for a personalized program plan for that animal. However this is not limited to other parts of the body that also target that specific area. Bowen does seem to take care of the body as whole instead of a specific area. Also in Rocky's case the autonomic nervous system is working sending messages to the brain because it controls involuntary movements of the organs like the kidneys.

Through this research I have learned way more than I expected to about an animal body. There also seems to be a lot of similarities with the human body. There is now two books that I would like to buy about the animal anatomy to further my education and assist me out with being a Bowen Practitioner. The names of those books are Millers Anatomy of the dog and Veterinary Notes for Dog Owners by Trevor Turner. I found these resources very valuable and knowledgeable for an ordinary person like me who is learning. This research has interested me so much that I would like to continue it further. Bowen has so many possibilities for me with the future that I can't wait to get my business up and started. I have learned to take Bowen as the whole body and not specific targets because that is what is does. Bowen is truly a universal way of therapy that is great for any living thing.