Walk the Dog
Hanne Grice
In association with Dog Listener

The canine brain - the function of the three main areas and how the brain receives and transmits information to and from all parts of the body

A dog's brain is a sophisticated organ that controls the dog's thinking, learning, and actions. It is responsible for interpreting and integrating information from all over the body. 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.[1] This illustrates how the brain is at the core of the dog's activity, busy digesting data and determining the best course of action, which affects the dog'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 and is responsible for receiving and analysing 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 the canine brain. As a result, the dog can perform numerous tasks and has complex behaviour patterns compared to the reptile.[2] 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.[3] Within these two areas are four lobes; the frontal, temporal, parietal and occipital lobe[4]. 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 a dog to selectively concentrate and focus on one thing at a time.[5] 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[6]. Once this information has been

---

[1] *Book: Fogle, Bruce (1992) The Dog's Mind, Pelham Books, chapter 2, page 14.*

[2] *Book: Strong, Val (1999) The dog's brain – a simple guide, Alpha Publishing, page 6.*

[3] *Internet: Wells, Virginia (copyrighted 1999-2008) Article 'Structure and Function of the Brain and Spinal Cords in Dogs', PetPlace.com, website address www.petplace.com*

[4] *Book: Strong, Val (1999) The dog's brain – a simple guide, Alpha Publishing, page 9.*

[5] *Book: Lindsay, Steven R., Burrows, George E., (2000) Handbook of Applied Dog Behaviour and Training Volume 1, Blackwell Publishing, chapter 3, page 78.*

[6] *The parietal lobes decode sensory information and the occipital lobes are responsible for decoding visual information. Both these lobes are referred to as the posterior lobes.*

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.[7]

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 the dog's drinking and eating behaviour, as well as its 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)[8]. In the book, Veterinary Notes for Dog Owners, it states that "emotions of rage and aggression also seem to originate in the hypothalamus…normally inhibited by the hippocampus and the frontal lobe of the cerebral cortex…The rabies virus invades the hippocampus and removes this inhibition so that the powerful aggressive urges of the hypothalamus are allowed to prevail."[9] This illustrates how a virus can directly affect the brain which in turn produces strange and unwanted behaviour in the dog. The dog's brain is a complex machine and within the cerebral cortex is the limbic system which regulates the dog's emotions from fear, rage, and aggression to anxiety, joy and euphoria, and it has an essential role in the learning process. As we can see from this example, 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 the dog's defence reactions at speed, rather than it being decoded first by the cerebral cortex which takes longer to process.[10]

---

[7] *Book: Turner, Trevor (edited by) (reprinted 2006) Veterinary Notes for Dog Owners, Popular Dogs Publishing Co. Ltd, chapter 13, page.224.*

[8] *Internet: Foster, Dr Race, Smithy, Dr Marty (copyrighted 1997-2008) The Nervous System: Normal Anatomy and Development, Foster & Smith Inc., PetEducation.com website address www.peteducation.com*

[9] *Book: Turner, Trevor (edited by) (reprinted 2006) Veterinary Notes for Dog Owners, Popular Dogs Publishing Co. Ltd, chapter 13, page.225.*

[10] *Book: Strong, Val (1999) The dog's brain – a simple guide, Alpha Publishing, page 12.*

The second area of the dog's brain is the **cerebellum** (meaning 'little brain' in Latin)[11]. 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 the dog. The cerebellum is interconnected via thalamic relays with the sensory-motor area of the cerebral cortex.[12] Therefore, the cerebellum will receive information from the cerebral cortex about intended muscle activity and it will process and compare this information from receptors in the 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.[13] 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, this means during the neonatal period the puppy is sluggish in its movements and pain sensation is very slow.

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 to go to the 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 regulates various functions including heart beat, breathing, salivation, coughing, sneezing and gastrointestinal functions.[14] 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

[11] *Internet: Exert from online book (2006), Compact Oxford English Dictionary, Oxford University Press, website address www.askoxford.com*
[12] *Book: Lindsay, Steven R., (2000), Iowa State Press, Handbook of Applied Dog Behaviour and Training, Volume 3, chapter 3, p.77*
[13] *Book: Turner, Trevor (edited by) (reprinted 2006) Veterinary Notes for Dog Owners, Popular Dogs Publishing Co. Ltd, chapter 13, page.225.*
[14] *Book: Lindsay, Steven R., Burrows, George E. (2000) Handbook of Applied Dog Behaviour and Training Volume 3, Blackwell Publishing, chapter 3, page 78.*

urethral sphincter activity and the relaxation of the bladder.[15] We can therefore assume that damage to the pons will contribute to urinary incontinence.

Having explored the three main areas of the canine brain, it is important to understand how the brain receives and transmits pieces of information. The central nervous system is comprised of the brain and spinal cord, but connected to these are a network of peripheral nerves (the peripheral nervous system) which penetrate and supply the tissues of the body and transmit pieces of information, for example 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**.[16] 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.[17] 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 in the immediate area of the dendrite of the receiving cell. This chemical secretion is known as the neurotransmitter. Chemicals secreted in the dog include dopamine, noradrenalin and serotonin. These three neurotransmitters are important in the treatment of canine behaviour problems. Neurotransmitters can excite, inhibit or alter the activity of other neurons.[18] 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

---

[15] *Internet: Journal - short report: Tohoku, J (1987) Pontine Urine Storage Centre in the Dog, part 153, p.77, website address www.journalarchive.jst.co.jp/english/top_en.php*

[16] *Book: Turner, Trevor (edited by) (reprinted 2006) Veterinary Notes for Dog Owners, Popular Dogs Publishing Co. Ltd, chapter 13, page.220.*

[17] *Internet: Jones, Tim M. (2003) Introduction to Neural Networks, Charles River Media Inc, Thunq.com, website address www.thunq.com*

[18] *Book: Strong, Val (1999) The dog's brain – a simple guide, Alpha Publishing, page 15.*

action from the excitatory transmitters have no effect.[19] Changes to the responses of synapses are believed to be the key to memory and learning.

In conclusion, the canine brain is a highly complex organ. It receives information from nerves through out the dog's body, interprets this information and determines a response back through the nerves, allowing the dog to function and survive. The sophistication of a dog's brain also allows for learning, emotion and behaviour, enabling the dog to respond and adapt to its environment.

[19] *Book: Strong, Val (1999) The dog's brain – a simple guide, Alpha Publishing, page 16.*