Anatomy of the Brain

The brain serves many important functions. It gives meaning to things that happen in the world surrounding us.

We have five senses: sight, smell, hearing, touch and taste.Through these senses, our brain receives messages, often many at one time. It puts together the messages in a way that has meaning for us, and can store that information in our memory. For example: An oven burner has been left on. By accident we touch the burner. Our brain receives a message from skin sensors on our hand. Instead of leaving our hand on the burner, our brain gives meaning to the signal and tells us to quickly remove our hand from the burner. Heat has been felt. If we were to leave our hand on the burner, pain and injury would result. As adults, we may have had a childhood memory of touching something hot that resulted in pain or watching someone else who has done so. Our brain uses that memory in a time of need and guides our actions and reactions in a harmful situation.

With the use of our senses: sight, smell, touch, taste, and hearing, the brain receives many messages at one time. It can select those which are most important. Our brain controls our thoughts, memory and speech, the movements of our arms and legs and the function of many organs within our body. It also determines how we respond to stressful situations (i.e. writing of an exam, loss of a job, birth of a child, illness, etc.) by regulating our heart and breathing rate. The brain is an organized structure, divided into many parts that serve specific and important functions.

Understanding the Nervous System

The nervous system is commonly divided into the central nervous system and the peripheral nervous system. The central nervous system is made up of the brain, its cranial nerves and the spinal cord. The peripheral nervous system is composed of the spinal nerves that branch from the spinal cord and the autonomous nervous system (divided into the sympathetic and parasympathetic nervous system). It controls our response to stressful situations.

For the purpose of this book, we will speak specifically about some of the functions and parts of the brain. This is not to say that the brain functions alone. The central and peripheral nervous systems play many interconnected and complex roles.

A Microscopic View of the Brain

The brain is made up of two types of cells: neurons and neuroglia. The neuron is responsible for sending and receiving nerve impulses or signals. Try to picture electrical wiring in your home. An electrical circuit is made up of numerous wires connected in such a way that when a light switch is turned on, a light bulb will beam. A neuron that is excited will transmit its energy to neurons that are within its vicinity. Remember the sequence of events of drawing your hand away from a hot oven burner. A series of excited, interconnected neurons made you withdraw your hand.

Neuroglia provide neurons with nourishment, protection and structural support. They are the most common types of cells involved in tumors that have originated in the brain. Astroglia or astrocytes, oligodendroglia and ependymal cells are the types of glial cells commonly found in the brain. The name given a brain tumor may reflect the type of cell that is involved e.g. astrocytoma (astroglia/astrocyte cells involved).
If you were to look under a microscope, you would be able to distinguish heart cells from brain cells. A neurosurgeon may remove tissue from a brain tumor to be studied by experts in the field of pathology. Pathologists, by identifying the type of cells that are present in brain tissue, will give brain tumor a particular name. Surgery, radiotherapy and/or chemotherapy may be used to effectively treat the tumor.

The Meninges

The brain is found inside the bony covering called the cranium. The cranium protects the brain from injury. Together, the cranium and bones that protect our face are called the skull.

Meninges are three layers of tissue that cover and protect the brain and spinal cord. From the outermost layer inward they are: the dura mater, arachnoid and pia mater.
In the brain, the dura mater is made up of two layers of whitish, inelastic (not stretchy) film or membrane. The outer layer is called the periosteum. An inner layer, the dura, lines the inside of the entire skull and creates little folds or compartments in which parts of the brain are neatly protected and secured. There are two special folds of the dura in the brain, the falx and the tentorium. The falx separates the right and left half of the brain and the tentorium separates the upper and lower parts of the brain.

The second layer of the meninges is the arachnoid. This membrane is thin and delicate and covers the entire brain. There is a space between the dura and the arachnoid membranes that is called the subdural space. The arachnoid is made up of delicate, elastic tissue and blood vessels of different sizes.

The layer of meninges closest to the surface of the brain is called the pia mater. The pia mater has many blood vessels that reach deep into the surface of the brain. The pia, which covers the entire surface of the brain, follows the folds of the brain. The major arteries supplying the brain provide the pia with its blood vessels. The space that separates the arachnoid and the pia is called the subarachnoid space. It is here where the cerebrospinal fluid (discussed next) will flow.

Cerebrospinal Fluid

Cerebrospinal fluid, also known as CSF, is found within the brain and surrounds the brain and the spinal cord. It is a clear, watery substance that helps to cushion the brain and spinal cord from injury. This fluid circulates through channels around the spinal cord and brain, constantly being absorbed and replenished. It is within hollow channels in the brain, called ventricles, where the fluid is produced. A specialized structure within each ventricle, called the choroid plexus, is responsible for the majority of CSF production. The brain normally maintains a balance between the amount of cerebrospinal fluid that is absorbed and the amount that is produced. Often, disruptions in the system occur.

The Ventricular System

The ventricular system is divided into four cavities called ventricles which are connected by a series of holes (called foramen) and tubes.

Two ventricles enclosed in the cerebral hemispheres are called the lateral ventricles (first and second). They each communicate with the third ventricle through a separate opening called the Foramen of Munro. The third ventricle is in the centre of the brain and its walls are made up of the thalamus and hypothalamus.

The third ventricle connects with the fourth ventricle through a long tube called the Aqueduct of Sylvius.

Cerebrospinal fluid flowing through the fourth ventricle gets around the brain and spinal cord by passing through another series of openings.

The condition, hydrocephalus, may occur when there is a blockage in the pathways through which the fluid normally travels. It may also arise from an overproduction of fluid or a difficulty in absorbing the fluid that is produced. Because the brain is enclosed within the bony skull, the extra fluid, trapped by blocked pathways, has no escape. This extra fluid within the brain will produce increased pressure symptoms: headaches, vomiting, drowsiness and in some cases, confusion.

Brain tumors may block the channels of cerebrospinal fluid within the brain. Rare tumors involving the choroid plexus within the ventricles may affect the production and absorption of the fluid. Spinal cord tumors may block the fluid as it travels around the spinal cord. A surgical procedure of shunting extra fluid may be necessary.

Cerebrum

The cerebrum, which forms the bulk of the brain, may be divided into two major parts: the right and left cerebral hemispheres. The cerebrum is often a term used to describe the entire brain. There is a fissure or groove that separates the two hemispheres, called the great longitudinal fissure (the falx of the dura is here). The two sides of the brain are joined at the bottom by the corpus callosum. The corpus callosum connects the two halves of the brain and delivers messages from one half of the brain to the other. The surface of the cerebrum (brain) contains billions of neurons and glia that together form the cerebral cortex.

The (cerebral) cortex appears greyish brown in color and is called the "gray matter". The surface of the brain appears wrinkled. The cerebral cortex has small grooves (sulci), larger grooves (fissures) and bulges between the grooves called gyri. Scientists have specific names for the bulges and grooves on the surface of our brain. They serve as landmarks and are used to help isolate very specific regions of the brain. Decades of scientific research have revealed the specific functions of the various regions of the brain. Beneath the cerebral cortex or surface of the brain, connecting fibres between neurons form the "white matter" (appear white in color).

The cerebral hemispheres have several distinct fissures. By finding these landmarks on the surface of a brain, the brain can effectively be divided into pairs of "lobes". Lobes are simply broad regions of the brain. The cerebrum or brain may be divided into pairs of frontal, temporal, parietal and occipital lobes. To state this in another way, each hemisphere has a frontal, temporal, parietal and occipital lobe. Each lobe may be divided, once again, into areas that serve very specific functions. It must be remembered that each lobe of the brain does not function alone. There are very complex relationships between the lobes of the brain.

Messages within the brain are delivered in many ways. The signals are transported along routes called pathways. Any destruction of brain tissue by a tumor can disrupt the communication between different parts of the brain. The result will be a loss of function such as speech, ability to read or ability to follow simple spoken commands. Messages can travel from one bulge on the brain to another (gyri to gyri), from one lobe to another, from one side of the brain to the other, from one lobe of the brain to structures that are found deep in the brain, e.g. thalamus or from the deep structures of the brain to another region in the central nervous system.

Researchers during neurosurgery have stimulated the surface of the brain with an electrode which delivered a very weak electrical shock. It has been found that specific regions of the motor and sensory regions, when electrically stimulated will cause movement or sensation to occur in a very specific part of the body. Touching one side of the brain sends the electrical signals to the other side of the body. If we touched the motor region on the right side of the brain, we would cause the opposite side or the left side of the body to move. Stimulating the left primary motor cortex would cause the right side of the body to move. The messages for movement and sensation will always cross to the other side of the brain and cause the opposite limb to move or feel a sensation. If your brain tumor is located on the right side of the brain in an area that controls the movement of your arm, your left arm may be weak or paralysed. One side of the brain controls the opposite side of the body.

Brain Lobes of the Brain

The following is a summary of the functions of parts of the brain and their location:

Frontal Lobes

The areas that produce movement of parts of the body are found in the primary motor cortex or precentral gyrus. These regions are found in the frontal lobes.

The prefrontal cortex plays an important part in our memory, intelligence, concentration, temper and personality. It helps us set goals, make plans and judge our priorities.

The premotor cortex is a region found beside the primary motor cortex. It guides our eye and head movements and sense of orientation. Broca's area, important in language production, is found in the frontal lobe, usually on the left side.

Occipital Lobes

These lobes contain regions that contribute to our visual field or how our eyes see the world around us. They help us see light and objects and allow us to recognize and identify them. This region is called the visual cortex.

The occipital lobe on the right interprets visual signals from your left visual space, while the left occipital lobe does the same for your right visual space. Damage to one occipital lobe may result in loss of vision in the opposite visual field.

Temporal Lobes

The primary auditory cortex helps us hear sounds and gives sounds their meaning, e.g. the bark of a dog. The temporal lobes are the primary region responsible for memory. It contains Wernicke's area (language and speech functions.)

Parietal Lobes

The parietal lobes interpret, simultaneously, sensory signals received from other areas of the brain such as our vision, hearing, motor, sensory and memory. Together, memory and the new information that is received give meaning to objects. A furry object touching your skin, that purrs and appears to be your cat, will have a different meaning than a furry object that barks and you see to be a dog.

Hypothalamus

The hypothalamus is a small structure that contains nerve connections that send messages to the pituitary gland. The hypothalamus handles information that comes from the autonomic nervous system. It plays a role in controlling our behavior such as eating, sexual behavior and sleeping, and regulates body temperature, emotions, secretion of hormones and movement. The pituitary gland develops from an extension of the hypothalamus downwards and from a second component extending upward from the roof of the mouth. These two components form the pituitary gland which sits in a specialized boney container at the base of the skull called the pituitary fossa. It is involved in controlling a number of hormonal functions including thyroid functions, functions of the adrenal glands, growth and sexual maturation. The posterior part of the pituitary gland regulates the formation of urine.

Pineal Gland

The pineal gland is an outgrowth from the posterior or back portion of the third ventricle. In some mammals, it controls the response to darkness and light. In humans, it has some role in sexual maturation although the exact function of the pineal gland in humans is unclear.

Thalamus

The thalamus serves as a relay station for almost all information that comes and goes to the cortex. It plays a role in pain sensation, attention and alertness.

Cerebellum

The cerebellum is located at the back of the brain beneath the occipital lobes. It is separated from the cerebrum by the tentorium (fold of dura). The cerebellum fine tunes our motor activity or movement, e.g. the fine movements of our fingers as they print a story or color a picture. It helps us maintain our posture, our sense of balance or equilibrium by controlling the tone of our muscles and senses the position of our limbs. A tumor affecting the cerebellum may cause an individual to stagger and sway when he/she walks or has jerky movements of the arms and legs (a drunken appearance). An individual trying to reach an object may misjudge the distance and location of the object and fail to reach the object. The cerebellum is important in one's ability to perform rapid and repetitive actions such as playing a video game. In the cerebellum, right-sided abnormalities produce symptoms on the same side of the body.

The brain stem is located in front of the cerebellum and may be considered as a "stem" or structure holding up the cerebrum. It consists of three structures: the midbrain, pons and medulla oblongata. It serves as a relay station, passing messages back and forth between various parts of the body and cerebral cortex. Many simple or primitive functions that are essential for survival are located here.

The midbrain is an important centre for ocular motion while the pons is involved with coordinating the eye and facial movements, facial sensation, hearing and balance.

The medulla oblongata controls our breathing, blood pressure, heart rhythms and swallowing. These functions are important to our survival. Messages from the cortex to the spinal cord and nerves that branch from the spinal cord are sent through the pons and the brain stem. Destruction of these regions of the brain will cause "brain death". The heart can no longer beat on its own. Lungs cannot work on their own. Unable to breathe, oxygen will not be delivered to the brain. Brain cells which require oxygen to survive will die.

The reticular activating system is found in the midbrain, pons, medulla and part of the thalamus. It controls our level of wakefulness, the attention we pay to what happens in the world that surrounds us and our pattern of sleep.

Originating in the brain stem are ten of the twelve cranial nerves that control hearing, eye movement, facial sensations, taste, swallowing and movement of the face, neck, shoulder and tongue muscles. The cranial nerves for smell and vision originate in the cerebrum. A tumor in this area may readily affect these nerves causing, for example, one eye to "turn in" and the child to complain of double vision or drooping of one side of the mouth with drooling.

Limbic System

This system is involved in our emotions. Included in this system are the hypothalamus, part of the thalamus, amygdala (active in producing aggressive behavior) and hippocampus (plays a role in our ability to remember new information).

Language and Speech Functions

Localization of Brain Functions Structures Deep inside the Brain

In general, the left hemisphere or side of the brain is responsible for language and speech. Because of this, it has been called the "dominant" hemisphere. The right hemisphere plays a large part in interpreting visual information and spatial processing. In about one third of individuals who are left-handed, speech function may be located on the right side of the brain. Left-handed individuals may need specialized testing to determine if their speech centre is on the left or right side prior to any surgery in that area.

There is an area in the frontal lobe of the left hemisphere called Broca area. It is beside the region that controls the movement of our facial muscles, tongue, jaw and throat. If this area is destroyed, there is difficulty in producing the sounds of speech. One is unable to move the tongue or facial muscles in the appropriate way to make words. The individual can still read and understand spoken language but has difficulty in speaking and writing (i.e. forming letters and words, doesn't write within lines). This problem is called Broca's aphasia.

There is a region in the left temporal lobe called Wernicke's area. Damage to this area causes Wernicke's aphasia. Words are heard but are meaningless (receptive aphasia). An individual can make speech sounds. These sounds however have no meaning for the individual is unable to understand what is said by him or others.
Many neuroscientists believe that the left hemisphere and perhaps other portions of the brain are important in language. An aphasia is simply a disturbance of language. Certain parts of the brain are responsible for specific functions in language production. There are many types of aphasias, each depending upon the brain area that is affected, and the role that area plays in language production.

Cranial Nerves

There are twelve pairs of nerves that come from the brain itself. These are called the cranial nerves. These nerves are responsible for some very specialized features and they have traditionally been both named and numbered.

Cranial Nerves

I Olfactory
II Optic
III Oculomotor
IV Trochlear
V Trigeminal
VI Abducens
VII Facial
VIII Acoustic
IX Glossopharyngeal
X Vagus
XI Accessory
XII Hypoglossal Function