

## CNS STRUCTURES AND FUNCTIONS: THE BRAIN

There are something in the order of 10,000,000,000 neurons in the brain, each of which might have between 1000 and 10,000 synaptic connections with other neurons. In fact, it has been estimated that there are more possible ways in which the neurons of a single human brain can be interconnected than there are atoms in the known universe! It is a wonder, then, that we know anything about the functions of the different structures in the brain at all. In fact, there are huge areas of the brain, particularly the cortex, that remain a mystery. However, there are some areas of the brain in which researchers have been able to localise functions.

The brain is usually subdivided into three parts: the forebrain, the midbrain and the hindbrain. The forebrain consists of the cerebral hemispheres (or cerebrum), the thalamus, the hypothalamus, the basal ganglia and the limbic system. The midbrain is at the top of the brainstem and connects the forebrain to the spinal cord; its main structure is the reticular activating system. The hindbrain consists of the cerebellum, the pons and the medulla oblongata.

### 1. The Forebrain

- ***Cerebrum***

The two hemispheres of the brain looks like a giant wrinkled walnut and makes up seven tenths of the entire nervous system. Its wrinkles are not haphazard and pointless, they enormously enlarge the surface of the brain so that it can be crammed inside the skull! The cerebral hemispheres are split down the middle by a deep rift: the longitudinal fissure, but are connected further down by a mass of joining fibres called the **corpus callosum**. The top layer of the cerebrum is the **cerebral cortex**. Its surface consists of grey matter (and is pinkish grey in colour) and below the surface the cerebrum consists of white matter.

Each cerebral hemisphere can be divided into the **frontal, occipital, temporal and parietal** lobes. The lobes are not exactly identified by their particular functions, but you can roughly say that the frontal lobes deal with the sense of smell, perhaps (in association with the limbic system) with emotions, they contain the motor cortex and Broca's area (left hemisphere only). The temporal lobes are concerned with hearing, containing the auditory cortex and, in the left hemisphere where the lobe borders the parietal lobe, Wernicke's area. The occipital lobes are implicated in vision, containing the visual cortex and the parietal lobes are implicated in visuo-spatial and body-sense (somatosensory) processes. As far as the motor and somatosensory cortex is concerned, they both show contralateral control, i.e. areas in the right hemisphere receive information about the left side of the body and areas in the left hemisphere receive information about the right side of the body. The crossing over takes place in a structure called the **medulla** in the hindbrain. Other parts of the brain also show some contralateral control, sometimes referred to as **lateralization of function**.

A bit more detail about **Wernicke's** and **Broca's** areas is needed. These areas have been identified as being two of the language areas of the brain. They are located *ONLY* in the left hemisphere of the brain and have different functions. It appears that Wernicke's area is concerned with language understanding. Damage to that part of the brain results in patients who cannot understand what is being said to them, can't figure out the written word and can produce only very poor speech. Broca's area appears to be concerned mainly with language production. Damage to Broca's area results in patients who can produce very little, if any, speech, but they can understand speech and can still read and write.

About 3/4 of the cortex remains a mystery and it is known as the **association cortex**. This is where the higher mental functions such as thinking, reasoning, learning etc. probably take place, but nobody has yet been able to localise these functions (and there is some doubt if they ever will!). The cortex is NOT crucial for survival. In fact some species, such as birds, do not have any cortex at all. The human brain has the largest proportion of association cortex than any other species.

- ***Thalamus***

There are two thalami in the brain, situated very deep in the forebrain between the brain stem and the cerebral hemispheres. The thalamus hands on information from the senses to the cerebrum and sends out instructions from the cerebrum to the body's muscles. It handles information fed in from the body via the spinal cord and it handles visual and auditory information too. It passes on information, which is involved with complex limb movements, from the cortex to the cerebellum. Yet another part of the thalamus plays a part in sleeping and waking. It is rather a vital structure.

- ***Hypothalamus***

This tiny structure (about the size of the tip of your index finger) just under the thalamus acts as an essential co-ordinator of the central nervous system. It plays a crucial part in our emotions and controls basic life processes (like the control of the body's internal environment, keeping your temperature constant, signalling when you are thirsty, controlling eating, controlling your sex drive etc.). It sends messages to the entire ANS and it influences the pituitary gland, which is the master gland of the endocrine system, controlling hormone secretion.

- ***Basal Ganglia***

These are made up of a number of smaller structures called the corpus striatum, the amygdala and the substantia nigra, all of which seem to be involved in muscle tone and posture. The amygdala has also been implicated as part of a short term memory system.

- ***Limbic System***

This is a set of interrelated structures that seem to nest inside each other. It includes three structures already mentioned, the thalamus, the hypothalamus and

the amygdala. It also contains 7 other structures, the **mamillary body**, the **anterior commissure**, the **septum pellucidum**, the **cingulate gyrus**, the **hippocampus**, the **fornix** and the **olfactory bulb**. This appears to be one of the oldest parts of the brain and is very similar to that of primitive mammals. It is sometimes called the nose brain because much of its development appears to have been involved in the sense of smell. It is closely involved in behaviours concerned with motivational and emotional needs, including feeding, fighting, escape and mating. Damage to, in particular, the hypothalamus could cause eating disorders and damage to other parts could cause emotional disorders such as increased aggression, disordered sex drive etc. Two of its structures, the hippocampus and the amygdala, appear to be involved in memory processes. For example, someone who has a damaged hippocampus will be very easily distracted and won't be able to carry out a task involving a whole series of actions because they will have forgotten what they wanted to do before they get to the end of the task. Also, people with hippocampal damage have extremely poor spatial memory, so might not be able to find their way home.

## 2. The Midbrain

There is only really one main structure in the midbrain (apart from structures that control the orienting reflex) and that is the **Reticular Activating System (RAS)**. This structure carries mainly sensory information in an ascending pathway from the spinal cord to the forebrain (**ARAS**) and carries mainly motor information in a descending pathway from the forebrain to the spinal cord. The ARAS is absolutely vital because it regulates our general level of alertness, whether we are conscious or not. It plays a very important part in the sleep-wake cycle too. Without it we might find ourselves permanently asleep. It also plays a part in selective attention, making it possible for us to screen out unwanted information.

## 3. The Hindbrain

This consists of three main structures- **Cerebellum**, **Pons** and **Medulla Oblongata**.

- **Cerebellum**

This consists of two hemispheres, accounts for about 11% of brain weight and plays a vital role in the co-ordination of movement. It controls balance and fine movements (such as reaching for things) and processes motor commands from higher brain centres before transmitting them to the muscles. Damage to this part of the brain can cause hand tremors, drunken movements and loss of balance. It acts like an automatic pilot in the brain so that once we have learned sequences of fine movements it can carry them out "automatically".

- **Pons**

This is a bulge of white matter that connects the two halves of the cerebellum. It is vital in co-ordinating the movements of the two halves of the body (without it you would not be able to catch a ball, dance etc.). It is also an important connection between the midbrain and the medulla.

- ***Medulla Oblongata***

This is yet another vital part of the brain that mediates very basic functions that we are not conscious of, controlling breathing, cardiac function, swallowing, vomiting, coughing, chewing, salivation and facial movements. It is, in evolutionary terms, the oldest part of the brain. The midbrain, the pons and the medulla together make up the brain stem. Any damage to the brain stem will almost certainly result in death.

There is just one further structure to mention in the brain that plays an important part in our functioning: that is the **corpus callosum**.

- **Corpus Callosum**

This is a dense mass of joining fibres that is four inches long and joins the two cerebral hemispheres. It allows the exchange of information from one hemisphere to another. There are some patients who, because of severe and uncontrollable epilepsy, have their corpus callosum cut. These are called **split brain patients**. The side effect of this is that the two hemispheres act like two brains in one head. A researcher called Sperry carried out a great deal of work on split brain patients. A typical experiment would involve photographs of different faces which have been cut down the middle and recombined inappropriately. They were then presented to subjects so that the left side of the photo would be available to the right hemisphere and vice versa. For example, an old man might be shown to the right hemisphere and a young girl to the left hemisphere. In this case, if asked what they had seen (asking for a response from the left, language hemisphere), they would say “old man”. However, if asked to point with their left hand to the complete photo of the person they had just seen (right hemisphere response) they would point to the young girl.. Two completely separate visual worlds in the same head, neither aware of the other. However, most recent research suggests that these findings were more to do with the unusual brains of these patients rather than truly different hemispheres and much recent research suggests that there is a great deal of cross over of function between the two hemispheres (e.g. Arnett, 1991) and they work very much together.