Bio Factsheet

Number 101

The Brain

The brain is vital for the coordination of responses and activities. This Factsheet summarises:

- **The position, structure and functions, of the human brain;**
- **Factors which affect brain function;**
- **The symptoms and causes of Alzheimer's disease as an example of brain malfunction.**

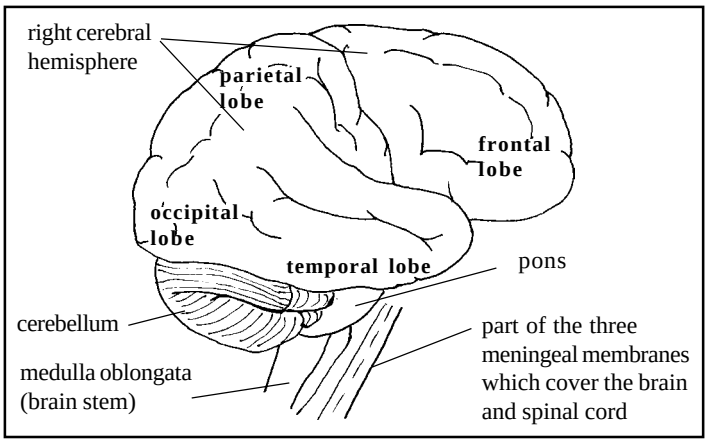
This Factsheet is restricted to the brain. Other factsheets, which cover closely related information that you may wish to refer to, are:
No. 20. Nerves and synapses.
No. 56. The autonomic nervous system.
No. 58. Reflex actions.

The structure of the human brain

The brain is the coordinator for the human body. It contains approximately 100 000 million nerve cells. The numerous connections made by the fibres of these cells are responsible for our capacity for conscious thought.

It is often thought that brain size is proportional to intelligence, on the basis that it has been observed that the size increased during the evolution of vertebrates. Mammals have the largest brain in relation to body size, making up roughly 2.33% of body weight.

Fig. 1 Side view of human brain



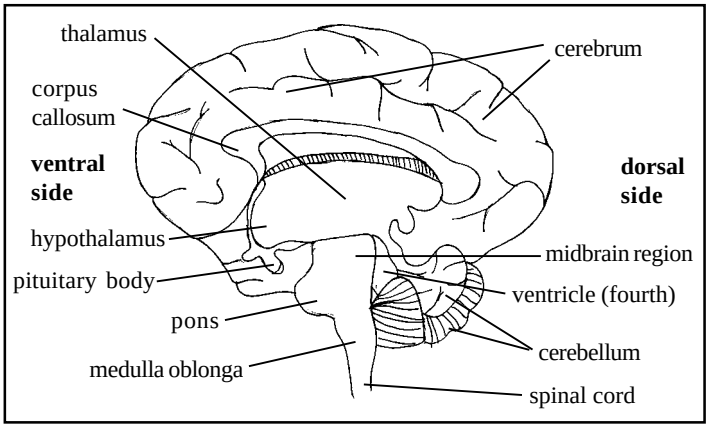
The basic structure of the brain is always the same. The main part is the **cerebrum** which is divided into two halves, called **cerebral hemispheres**, which are found either side of the **brain stem.** The left and right cerebral hemispheres are connected by a mass of nerve fibres called the **corpus callosum**. Each cerebral hemisphere consists of four main lobes: the frontal, temporal, occipital and parietal lobes. The **medulla oblongata** gradually tapers into the spinal cord. At the back of the main brain (**cerebrum**) is the **cerebellum** (or 'little brain').

The brain and the spinal cord make up the central nervous system (CNS). Like the spinal cord the brain is made of grey and white matter, and has a central canal, which in the brain is expanded into cavities called ventricles. The brain and spinal cord are surrounded by a protective three-membrane system called the **meninges**. The space between the inner two meningal membranes is filled with **cerebro-spinal fluid** (**CSF**), as are the ventricles and central canal.

The CSF is a type of lymph which effectively bathes the brain and spinal cord as it is contact with both the inside and outside. It provides the neurones with vital nutrients and oxygen, and removes waste products. It also contains lymphocytes to prevent infection. To assist the circulation of CSF, the epithelial cells lining the ventricles and central canal have cilia on their surface.

Remember *- inflammation of the meninges is* ***meningitis*** *which is caused by a viral or bacterial infection of the meninges.*

Fig 2 Vertical section through a human brain



Exam hint *- watch your spelling! Some brain regions if spelt incorrectly can be confused, for example the cerebellum and the cerebrum.*

The embryonic brain contains three regions, the forebrain, midbrain and hindbrain. These structures differentiate into the more complex adult structures of the brain:

Table 1. Regions of the brain

Embryonic brain	Adult brain
Forebrain	Cerebral hemispheres, hypothalamus, thalamus
Midbrain	Midbrain
Hindbrain	Medulla oblongata, cerebellum and pons

Functions of the parts of the brain

The functions of the brain are localised into specific regions. It has been possible to assign functions to the different regions by a number of techniques. Originally the only data available was from patients who had suffered a brain trauma. By determining which part of the brain had been damaged and observing the effect of the damage, a function for that area could be suggested. More recently, however, electrodes have been used to stimulate specific regions of the brain and the response observed. Modern techniques such as MRI (magnetic resonance imaging) scans have given information as to which areas of the brain are stimulated during different activities.

***Exam Hint** - make sure you know which parts of the brain are listed in your specification – different boards ask for different regions.*

Thalamus: Chiefly acts as a relay centre between parts of the brain, such as the cerebellum and cerebrum. It is also thought to be the sight of perception of pleasure and pain.

Hypothalamus: This has a wide variety of functions:

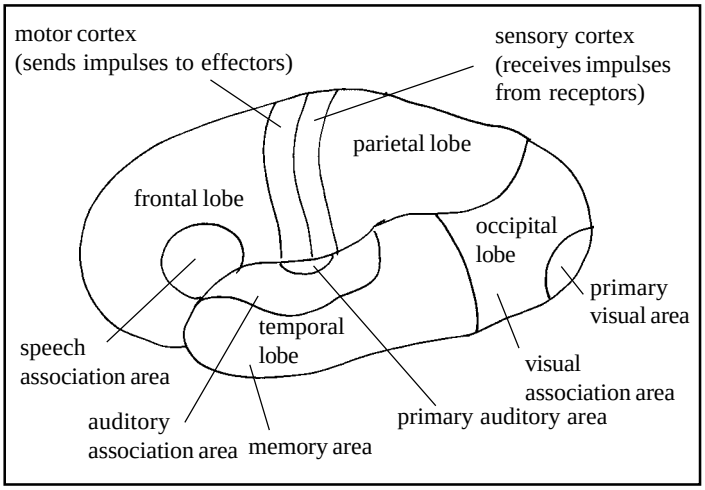
- It is a vital component for the autonomic (involuntary) nervous system, and contains control centres for the sympathetic and parasympathetic nervous systems. This enables it to have roles in homeostatic mechanisms such as osmoregulation and maintenance of body temperature – thus it contains the osmoregulatory centre, the thirst centre and the thermoregulatory centre.
- It functions as an endocrine gland, and synthesises the hormones released by the posterior pituitary gland. For example, the hypothalamus monitors the solute concentration of the blood. If this increases (and therefore the water level has decreased) the hypothalamus will secrete the hormone **ADH** (**antidiuretic hormone**), which travels through nerve cells to the posterior pituitary where it enters the blood. The hormone then travels to the kidney where it causes increased water reabsorption. Another hormone released by the hypothalamus, via the posterior pituitary, is **oxytocin**. This hormone has a role in controlling blood pressure, and also regulates uterine contractions during childbirth and milk release during suckling.
- The hypothalamus releases hormones called **releasing factors** which regulate the secretion of other hormones. For example, **gonadotropin releasing factor** (GnRF) regulates the secretion of FSH (follicle stimulating hormone) and LH (luteinising hormone) from the anterior pituitary. Other releasing factors regulate the thyroid and adrenal cortex hormones.
- The hypothalamus controls several daily behavioural patterns (circadian rhythms) such as sleeping and feeding. It also regulates aggression.

Cerebrum: Generally, the cerebral hemispheres receive and interpret sensory information, and stimulate the appropriate effector. It is also associated with memory, learning and reasoning, as well as consciousness, the least understood of the brain's functions. The outer 3mm of the hemispheres, the **cerebral cortex** is possibly the most complex region of the brain. It consists of many **association areas**, whose function is to allow an individual to interpret information on the basis of previous experience. These contain areas such as the **visual association area,** which allows the recognition of objects, therefore receiving information from the eyes.

If this area is damaged, visual images cannot be processed for example, a person may see an old friend, but will not recognise them. Also found here is the **auditory association area** allowing the recognition of sounds.

The **speech effector centre** receives information from the ears and coordinates the movement of the lips and the tongue as well as breathing to allow speech. If this area is damaged it may result in a person not being able to find the correct word for an object, or they may have difficult in forming coherent sentences. Also present are **silent areas** which produce no response when stimulated, therefore they may have a role in personality.

Fig. 3 Main areas of the left cerebral hemisphere



The midbrain: This acts as a link between the hind- and forebrain. Also situated here are the centres controlling visual and auditory reflexes.

Medulla oblongata: Like the hypothalamus this contains centres of the autonomic nervous system, which control activities such as breathing rate, heart rate and blood pressure. It also controls swallowing, coughing and vomiting. It links the brain to the spinal cord.

Cerebellum: This area coordinates the muscular movement initiated by the cerebrum. If it becomes damaged these movements become jerky and uncoordinated. It also receives impulses from the vestibular apparatus of the inner ear enabling it to maintain balance and posture.

Pons: The main centre in the pons is the **pneumotaxic centre,** which together with the breathing centres in the medulla oblongata, regulates breathing. It also functions as a bridge between the two cerebral hemispheres and as a link between the cerebrum and the medulla oblongata.

Table 2. Summary of brain functions

Region	Function
Thalamus	• Relay centre • Perception of pleasure and pain
Hypothalamus	• Control of osmoregulation • Control of body temperature • Synthesis of hormones for release by the posterior pituitary • Synthesis of hormone releasing factors • Control of circadian rhythms
Cerebrum	• Conscious thought, also learning, memory and reasoning • Interpretation of sensory information on the basis of past experience • Initiation of movement by skeletal muscles • Control of speech
Midbrain	• Links the forebrain and the hindbrain • Contains centres controlling auditory and visual reflexes
Pons	• Regulates breathing • Links higher brain regions to medulla oblongata
Medulla Oblongata	• Contains centres for control of breathing rate, heart rate and blood pressure • Controls involuntary actions such as swallowing and coughing • Links brain to spinal cord
Cerebellum	• Controls muscular movement and co-ordination • Regulates balance and posture

Exam hint *- when writing the functions make sure you always say, for example, 'control of osmoregulation' as just 'osmoregulation' would not get the marks.*

Alzheimer's Disease

If nerve cells are damaged they are not replaced by cell division as their cell cycle is too long and they are too specialised. Therefore the number of brain cells decreases with age, which can be linked to general decline in brain function, such as memory and problem solving. In extreme cases this can lead to **dementia**, one specific type being **Alzheimer's disease**. This condition commonly develops in the elderly. When the brains of sufferers were examined it was observed that they were smaller as a result of the loss of neurones, and they contained protein 'plaques' outside the brain cells and tangles of proteins inside. The areas mainly affected were parts of the cerebral hemispheres affecting conscious thought and memory. It is thought that these plaques and tangles are the result of the accumulation of abnormal proteins.

The visible symptoms of Alzheimer's disease are that sufferers lose intellectual functions such as the recall of facts and the ability to learn new information. Although the memories are still there they cannot easily be accessed. It is only possible to definitely diagnose Alzheimer's disease by examining the brain after death. The causes of this disease are not fully understood, but there is thought to be a familial predisposition, and a link to high levels of aluminium in the body.

The effects of drugs on the brain

The efficient functioning of the brain relies on chemicals called **neurotransmitters** released at synapses between neurones. Drugs such as alcohol and nicotine can affect the release and functioning of these substances.

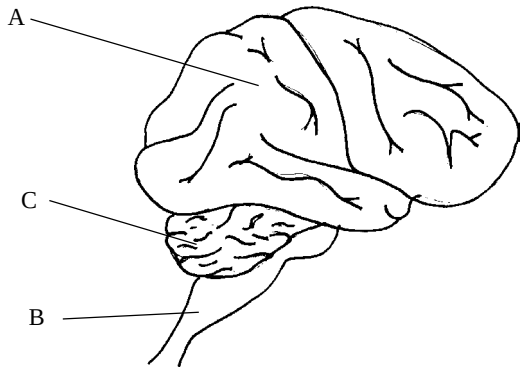
- Alcohol inhibits the metabolism of a neurotransmitter called **noradrenaline** which is responsible for excitation within the brain, therefore alcohol acts as a depressant. It also results in brain damage, leading to memory loss and difficulty in learning. This is due to the formation of morphine-like substances produced when alcohol reacts with other neurotransmitters such as **dopamine**. It is these substances that are also responsible for alcohol dependency.
- Nicotine functions as a stimulant by effecting the action of excitatory neurotransmitters. Thus nicotine mimics the action of **acetylcholine** on certain (not all) receptors, called **nicotinic receptors**, resulting in the depolarisation (stimulation) of neurones or effectors.
- Caffeine acts as a stimulant by causing the release of dopamine, which stimulates 'reward' pathways in the brain.
- Drugs such as morphine and heroin are classed as **opiates** in that they bind to the opiate receptors in the brain. This suppresses pain by binding to the postsynaptic membrane and blocks the normal synaptic transmission that would result in the sensation of pain.
- LSD functions by mimicking some of the actions of **serotonin**, a transmitter linked to the control of moods, such as mania, depression and elation, resulting in its hallucinogenic properties.

Acknowledgements:
This Factsheet was researched and written by Fiona MacBain
Curriculum Press, Unit 305B, The Big Peg, 120 Vyse Street, Birmingham. B18 6NF

ISSN 1351-5136

Practice Questions

1. The diagram below shows a human brain as seen from the side.



(a) Name the parts labelled A, B and C. 3
(b) Suggest and explain a reason for the folding of part A. 3
(c) State three functions of part B. 3

2. (a) Complete the following table:

Region of the brain	One function
	Control of heartbeat
Cerebellum	
	Control of osmoregulation
Cerebrum	

4

3. Describe the actions of the following drugs on the brain;
(a) alcohol. 4
(b) nicotine 3
(c) caffeine. 2

Answers

1. (a) A = cerebrum/cerebral hemisphere;
B = medulla oblongata;
C = cerebellum; 3
(b) folding increases the surface area/volume of A;
increases brain complexity/enables more neurones to be contained;
more neurones can make more connections with other cells; 3
(c) regulates heartbeat (frequency and force);
regulates breathing (depth and frequency);
regulates blood pressure/coughing/swallowing/vomiting/sneezing;
links brain to spinal cord; max 3

2.

Region of the brain	One function
medulla oblongata;	Control of heartbeat
Cerebellum	**control of balance/ control of fine movement;**
hypothalamus;	Control of osmoregulation
Cerebrum	**control of voluntary movement/conscious thought/ interpretation of sensory information;**

4

3. (a) inhibits the metabolism of noradrenaline;
results in brain damage;
due to the formation of morphine-like substances;
by reacting with other neurotransmitters such as dopamine; 4
(b) nicotine mimics the action of acetylcholine;
on nicotinic receptors;
resulting in excitation of effectors; 3
(c) causes the release of dopamine;
stimulating 'reward' pathways in the brain; 2