

**SUGGESTED TEXTBOOK ANSWERS****Chapter 5 The central nervous system**

The following are suggested answers only. Other answers to the same questions may also be correct.

**Science inquiry****Activity 5.1 The brain****What to do**

- 2** Notice the folding of the cerebrum. These are called convolutions. A human brain has many more convolutions than a sheep. What is the significance of the larger number of convolutions in a human compared with a sheep?

*Answer:* The grey matter of the cerebrum, consisting of nerve cell bodies, is at the surface of the cerebrum. The convolutions increase the surface area of the cerebrum and therefore increase the number of nerve cells. More neuronal connections are possible, resulting in humans having greater intelligence than a sheep.

- 3** Shallow downfolds on the surface of the cerebrum are called sulci; deep downfolds are called fissures. Locate a sulcus and a fissure. Describe the difference between them.

*Answer:* Fissures are much deeper than sulci.

- 4** Using Figure 5.6 (on page 63) locate the four lobes that can be seen on the outside of the cerebrum.

- 5** Locate the deep cleft that divides the cerebrum into two halves, or hemispheres.

- 6** Using forceps, peel off a little of the membrane that covers the surface of the cerebrum. This membrane is the inside layer of the meninges. What is the function of this inner meningeal layer?

*Answer:* The inner meningeal layer contains many blood vessels and adheres to the surface of the brain and spinal cord. It protects the surface and supplies the cells with oxygen and nutrients.

- 7** Using a scalpel in the cleft between the two hemispheres of the cerebrum, cut the brain lengthwise into two halves. Notice that the inside of the brain is moist. What is the fluid that fills spaces inside the brain? Where does the fluid come from and what is its function?

*Answer:* The fluid filling the spaces in the brain is cerebrospinal fluid (CSF). CSF is formed from the blood. It has three functions – protection, support and transport.

- Protection: CSF cushions the brain from any bumps or blows to the head.
  - Support: CSF surrounds the brain so that the brain is floating in, and supported by, the fluid.
  - Transport: CSF circulates around and through the brain taking nutrients and oxygen to the brain cells and removing carbon dioxide and other waste.
- 8** Describe the appearance of the corpus callosum at the base of the cerebral hemispheres

*Answer:* The corpus callosum appears as a white fibrous structure.

- 9 Draw a diagram of one side of the brain looking at the cut surface. Label the meninges, cerebrum, cerebellum, medulla oblongata, spinal cord, the four lobes, convolutions, a fissure and a sulcus.

*Answer:* See Figures 5.4, 5.5 on page 62 and 5.9 on page 65.

- 10 Using a scalpel, slice into the cerebrum and look at the cut surface. Which is at the surface of the cerebrum, grey matter or white matter?

*Answer:* Grey matter

- 11 Cut open the cerebellum. Are the grey and white matter arranged in the same way as in the cerebrum?

*Answer:* Yes, the white matter is a branched area with the grey matter outside it. See Figure 5.10 on page 65.

## Activity 5.2 Phineas Gage

- 1 How is it possible that, with damage to such a large and vital part of the brain, Gage was able to function relatively normally?

*Answer:* The rod clearly missed the parts of the brain that are responsible for vital functions: the medulla, cerebellum and hypothalamus. These parts must have been undamaged.

- 2 Changes in a person's functioning or behaviour as a result of injury to the brain were used by scientists to determine the functions of the affected parts of the brain. Were scientists able to learn anything about the brain from Gage's injury?

*Answer:* Hypotheses were advanced at the time of Gage's accident but none of these can be substantiated because of the following:

- The parts of the brain that were injured were inferred from the points of entry and exit of the iron rod. However there must have been much more damage than that caused by the passage of the rod. Fragments of bone would have been pushed into other parts of the brain and there would have been massive bleeding placing pressure on the brain.
- There is insufficient knowledge about Gage's behaviour before and after the accident to be able to make any conclusions about behavioural functions in the brain.

- 3 Did Gage's injury have any positive benefits for medical science?

*Answer:* Recent analyses of Gage's post-accident history have determined that he was able to function fairly normally and was a reliable employee. This shows that some cases of severe brain injury resulting in behavioural change can be overcome by social adjustment.

## Review questions

- 1 Describe the three structures that protect the central nervous system.

*Answer:* The central nervous system is protected by:

- bone – the cranium and the vertebrae
- meninges – three layers of membranes that cover the whole of the CNS
- cerebrospinal fluid – a fluid that cushions the CNS from bumps and shocks.

**2** What is cerebrospinal fluid? Where does it come from, where does it go to and what does it do?

*Answer:* Cerebrospinal fluid (CSF) comes from tissue fluid that has been forced out of blood capillaries. It circulates around and through the central nervous system, eventually re-entering the capillaries. As it circulates, it supplies nutrients to the cells of the brain and spinal cord and carries away their wastes. CSF surrounds the brain and spinal cord giving support and protecting the CNS by cushioning any blows or shocks.

**3 a** What is the cerebral cortex?

*Answer:* The cerebral cortex is the grey matter that forms a layer 2–4 millimetres thick on the outside of the cerebrum.

**b** List the advantages of having the cerebral cortex folded.

*Answer:* The folding of the cerebral cortex greatly increases its surface area. Since the cortex is grey matter, made up of the cell bodies of nerve cells, the folding means that the cortex can contain many more nerve cells than if it were not folded.

**c** What is the difference between a sulcus and a fissure?

*Answer:* Shallow downfolds of the cerebral cortex are called sulci (singular: sulcus). Fissures are much deeper downfolds.

**4 a** What are the functions of the cerebral cortex?

*Answer:* The cerebral cortex is involved in higher-order mental activities such as thinking, reasoning, learning, memory, intelligence, emotions and sense of responsibility. It also makes us consciously aware of input from the sense organs and initiates and controls voluntary muscle contractions.

**b** Name the three types of area in the cerebral cortex and give the function of each type.

*Answer:* The three types of functional area in the cerebral cortex are:

- sensory areas, which interpret impulses received from receptors
- motor areas, which consciously control muscular movements
- association areas, which process intellectual and emotional responses.

**5 a** Describe the location of the corpus callosum.

*Answer:* The corpus callosum is at the base of the longitudinal fissure that divides the cerebrum into two hemispheres. It is underneath the cerebrum.

**b** Why is the corpus callosum white?

*Answer:* The corpus callosum is white because it is made up of myelinated nerve fibres that link the two cerebral hemispheres.

**c** What is the function of the corpus callosum?

*Answer:* The nerve fibres of the corpus callosum allow the two sides of the cerebrum to communicate with each other. They allow nerve impulses to be sent from one cerebral hemisphere to the other.

**6 a** Describe the location of the cerebellum.

*Answer:* The cerebellum is underneath and at the back of the cerebrum.

**b** What is the main function of the cerebellum?

*Answer:* The cerebellum receives impulses from the inner ear and from stretch receptors in the voluntary muscles. Using that information, it controls posture and balance and it coordinates the fine movements of voluntary muscles.

**7 a** Describe the location of the hypothalamus.

*Answer:* The hypothalamus is in the middle of the brain. It is underneath the cerebrum and just above the pituitary gland.

**b** List some of the functions of the hypothalamus.

*Answer:* The hypothalamus controls many activities relating to homeostasis including:

- regulation of heart rate and blood pressure
- secretion of digestive juices and movement of the alimentary canal
- the diameter of the pupil
- body temperature
- food and water intake
- patterns of waking and sleeping
- contraction of the urinary bladder
- emotional responses such as fear, anger, aggression, pleasure and contentment
- secretion of certain hormones and coordination of parts of the endocrine system.

**8 a** Describe the location of the medulla oblongata.

*Answer:* The medulla oblongata is the part of the brain that joins the spinal cord. It is approximately 3 cm long and extends upwards from just above the point where the spinal cord enters the skull.

**b** What are the three important centres that are contained within the medulla oblongata?

*Answer:* The medulla oblongata contains:

- the cardiac centre, for regulating the rate and force of heartbeat
- respiratory centres, for controlling rate and depth of breathing
- the vasomotor centre, for regulating the diameter of blood vessels.

**9** Describe the location of grey matter in the spinal cord. How does its location differ from that in the cerebrum and cerebellum?

*Answer:* The grey matter of the spinal cord is in the centre of the cord. When seen in cross section the grey matter has a H shape. White matter surrounds the grey matter in the spinal cord. This is different from the cerebrum and cerebellum where the grey matter is on the outside and white matter inside.

## Apply your knowledge

- 1 If a person receives a heavy blow to the back of the head, the sensation experienced is often described as 'seeing stars'. Can you suggest a reason why a person would see stars as a result of such a blow?

*Answer:* The part of the brain that processes visual information is in the occipital lobe at the back of the cerebrum (see Figure 5.8 on page 64). The jolt received by the brain from the blow to the back of the head may result in some temporary disturbance to the nerve cells in this area. This temporary disturbance may result in the blurring of normal vision or 'seeing stars'.

- 2 After sustaining a head injury in a car accident, a person had difficulty chewing and swallowing. What part of the brain could have been damaged?

*Answer:* The medulla oblongata may have been damaged, because this contains the control centre for swallowing. Also, the upper motor neurons that pass through and cross over in the medulla may have been damaged, thus affecting the mouth and jaw movements involved in chewing. Another possibility is damage to the cerebellum, which is responsible for the coordination of voluntary muscle contraction.

- 3 Paraplegia, inability to move the legs, may be caused by an injury to the spinal cord. Explain why such an injury could result in paraplegia.

*Answer:* One of the functions of the spinal cord is to carry sensory impulses towards the brain and motor impulses away from the brain. If the spinal cord is damaged or severed above the point at which the motor neurons exit to the legs, then the nerve impulses cannot reach the leg muscles to stimulate muscle contraction. In the same way, the damage to the spinal cord prevents the brain from receiving sensory impulses from the legs so the person has no feeling in the limbs.

- 4 Some of the functions of the hypothalamus are achieved through the pituitary gland. How does the hypothalamus influence the pituitary?

*Answer:* The hypothalamus influences the pituitary gland by:

- producing hormones, which are passed to the pituitary gland for storage, e.g. oxytocin and antidiuretic hormone
- producing regulating hormones that control the release of pituitary hormones, e.g. growth hormone releasing factor and thyrotropin releasing factor.

- 5 A person could survive complete destruction of one of the cerebral hemispheres, which make up nearly 40% of the volume of the brain. By contrast, destruction of the hypothalamus, which is only about the size of an almond, would result in certain death. Explain the reasons for this difference.

*Answer:* A person can survive destruction or removal of one cerebral hemisphere because the other cerebral hemisphere is still functional. Impairment of some, or many, functions would be likely. Removal of a cerebral hemisphere (hemispherectomy) is sometimes performed in severe cases of epilepsy that do not respond to any other treatment.

It would not be possible to survive destruction of the hypothalamus because it is responsible for the regulation of many functions, such as heart rate, blood pressure, body temperature and secretion of digestive juices.

- 6 In severe cases of epilepsy, as a last resort, the corpus callosum may be severed so that the two cerebral hemispheres can no longer communicate with each other. Patients who have had this procedure are commonly referred to as having a 'split brain'. As each of the two cerebral hemispheres has separate functions, a split brain has a significant impact on the performance of simple tasks. Use references to find out the effects that a split brain would have on a person's functioning.

*Answer:* Severing of the corpus callosum (corpus callosotomy) may not produce any obvious impairment of functions. The most common difficulties relate to speech and some patients are unable to follow verbal instructions that require the use of their non-dominant hand. Careful experiments have shown that when the patient's left and right eyes see different images (split pictures) the person can describe the picture seen with the right eye, but when asked to point to what was described, the person points to the picture seen with the left eye. This occurs because the centre controlling speech is in the left cerebral hemisphere and the centre that interprets visual and spatial information is in the right hemisphere (in most people). The two hemispheres are unable to communicate with each other because the corpus callosum has been cut.