

SUGGESTED TEXTBOOK ANSWERS

Chapter 4 Divisions of the nervous system

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

Science inquiry

Activity 4.1 An autonomic reflex

- 1 What change was observed in the subject's pupils when the eyes were opened?

Answer: The pupil gets smaller in diameter.

- 2 What change was observed in the subject's iris when the eyes were opened?

Answer: The width of the iris increased.

- 3 Why is the response that you observed described as a reflex?

Answer: It has the four characteristics of a reflex:

- It occurs without conscious thought.
- It occurs automatically.
- It is rapid.
- The response is always the same.

- 4 Many reflexes are described as protective. Is the reflex that you observed a protective reflex? Explain.

Answer: Yes, because it is protecting the retina of the eye from being damaged by receiving light that is too intense.

- 5 Would it be possible to consciously prevent the response that you observed from occurring?

Answer: No, because the muscles of the iris are not under conscious control; they are controlled by the autonomic nervous system.

- 6 Which division of the autonomic nervous system caused the response that you observed?

Answer: The parasympathetic division

- 7 Optometrists place drops of a drug in the eyes to dilate the pupils so that the eyes can be examined. The drug blocks receptors for acetylcholine. Suggest why such a drug placed in the eyes could cause the pupil to dilate.

Answer: Acetylcholine is the neurotransmitter responsible for the transmission of nerve impulses in the parasympathetic nervous system. If acetylcholine receptors on the muscles of the iris are blocked, the muscles cannot receive messages transmitted by acetylcholine.

Review questions

- 1 How many pairs of nerves arise from each of the brain and spinal cord?

Answer: There are 12 pairs of cranial nerves arising from the brain and 31 pairs of spinal nerves.

- 2 What is a mixed nerve?

Answer: Mixed nerves have both sensory and motor fibres; that is, fibres that carry impulses into the CNS, as well as fibres that carry impulses away from the CNS.

- 3 On what sort of nerve would you find a ventral and dorsal root? Explain where these roots are located.

Answer: Each of the spinal nerves is joined to the spinal cord by a ventral and a dorsal root. The roots are located where the spinal nerve joins the spinal cord. Each ventral root contains axons of motor neurons that have their cell bodies in the grey matter of the spinal cord. Each dorsal root contains axons of sensory neurons that have their cell bodies in a small swelling on the dorsal root known as the dorsal root ganglion.

- 4 If the ventral root of a spinal nerve were damaged, would it affect the sensory functions or the motor functions of that nerve? Explain.

Answer: It would affect the motor functions because the axons of motor neurons are in the ventral root of a spinal nerve.

- 5 a What is the difference between the afferent and efferent divisions of the peripheral nervous system?

Answer: The afferent (or sensory) division of the peripheral nervous system has fibres that carry impulses into the central nervous system. The efferent (or motor) division has fibres that carry impulses away from the central nervous system.

- b What is the difference between the somatic and autonomic divisions of the efferent division of the peripheral nervous system?

Answer: The somatic division carries impulses from the central nervous system to the skeletal muscles; the autonomic division carries impulses from the central nervous system to heart muscle, involuntary muscle and glands. The autonomic division is further subdivided into the sympathetic division and the parasympathetic division.

- 6 Explain the relationship between the autonomic nervous system, the efferent division and the peripheral nervous system.

Answer: The peripheral nervous system encompasses everything outside the brain and spinal cord (that is, everything except the central nervous system). The efferent division of the peripheral nervous system is made up of nerves that carry messages from the brain and spinal cord to muscles (both skeletal and involuntary) and glands. The autonomic nervous system is that part of the efferent division that carries impulses to involuntary muscles and glands.

7 Describe four differences between the somatic and autonomic divisions of the peripheral nervous system.

Answer: See Table 4.1 on page 53 of the textbook.

Students could mention any four of the following:

- The nerve fibres of the autonomic nervous system carry impulses to the heart muscle, involuntary muscle of internal organs, and to glands. The somatic division carries impulses to skeletal muscles.
 - The pathway travelled by an impulse from the CNS to an organ via the autonomic division consists of two neurons. In the somatic division there is only one. One of the neurons in the autonomic system has its cell body in the central nervous system, but the cell body of the other is in a ganglion.
 - Most organs under autonomic control receive two sets of nerve fibres – sympathetic fibres and parasympathetic fibres; the skeletal muscles, under the control of the somatic division, receive only one set.
 - In the somatic division, the neurotransmitter that carries the message from the neuron to the skeletal muscle is acetylcholine; in the autonomic division, either acetylcholine or noradrenaline carry the message to the effector.
 - Control exercised by the autonomic division is usually involuntary; control exercised by the somatic division is usually voluntary.
 - Fibres from the somatic division always excite the target muscle; in the autonomic division, sympathetic fibres usually excite the target muscle or gland; whereas parasympathetic fibres usually inhibit the muscle or gland.
- 8 In general terms, what is the difference between responses brought about by the sympathetic and parasympathetic divisions of the autonomic nervous system?

Answer: The parasympathetic division generally produces responses that maintain the body during relatively quiet conditions. On the other hand, the sympathetic division tends to produce responses that prepare the body for strenuous physical activity. (Responses produced by the sympathetic division are often called fight-or-flight responses, because they prepare the body for situations that may involve aggression or fleeing from a threat.)

9 a List four stimuli that could lead to a fight-or-flight response.

Answer: Stimuli that could lead to a fight-or-flight response are fear, anger, stress, danger, competition or threat.

b List four responses that would prepare the body for fight or flight.

Answer: Students could mention any four of:

- increased rate and force of contraction of the heart (accompanied by increase in blood pressure)
- dilation of blood vessels in organs involved in strenuous activity (such as the skeletal muscles, heart and liver)
- constriction of blood vessels of organs not involved in activity (like the kidney, stomach, intestines and skin)
- dilation of airways in the lungs
- increased rate and depth of breathing
- rise in blood glucose level (because the liver converts more glycogen to glucose)
- increased secretion from sweat glands
- release (from the adrenal medulla) of the hormones adrenaline and noradrenaline, which intensify and prolong the above responses.

See also Table 4.2 on page 54 of the textbook.

10 What is a ganglion?

Answer: A ganglion is a group of nerve cell bodies found outside the central nervous system.

11 Describe three differences between the action of nerves and that of hormones.

Answer: Differences between the action of nerves and hormones include the following:

- Nervous responses are usually more rapid than hormonal ones, because nerve impulses travel rapidly along nerve fibres, while hormones are transported in the bloodstream.
- Nerve impulses bring about an immediate response, which lasts for only a short time. Hormones are typically slower acting and responses can last a considerable time, even years.
- Nervous messages are an electrochemical change that travels along the membrane of a neuron. Endocrine messages are hormones, chemical substances that are usually transported by the blood.
- Nerve impulses travel along a nerve fibre to a specific part of the body, and often influence just one effector. Hormones travel to all parts of the body, carried by the blood, and often affect a number of different organs.

12 Describe some of the similarities between the nervous and the endocrine systems.

Answer:

- Substances such as noradrenaline, antidiuretic hormone and dopamine function as both hormones and as neurotransmitters.
- Neurons secrete some hormones, such as oxytocin and adrenaline.
- Some hormones and neurotransmitters have the same effect on the same target cells. For example, noradrenaline and the hormone glucagon both act on liver cells to cause glycogen to be broken down to glucose.

Apply your knowledge

1 It is sometimes said that the sympathetic division of the autonomic nervous system produces fight-or-flight responses, while the parasympathetic is concerned with 'rest and digest'. Do you think these are appropriate descriptions for the two divisions? Explain your answer.

Answer: These are appropriate descriptions, because the sympathetic division is stimulated by situations that make a person either want to fight or run away. This division prepares the body for increased activity by increasing heart rate, breathing rate and sweating, while decreasing digestive functions. This is opposite to the effects of the parasympathetic division, which causes heart and breathing rates to decrease, and digestive functions to return to normal.

Students may say that these descriptions are not appropriate because a person's state at any time depends on the balance between sympathetic and parasympathetic impulses.

2 Urinary retention (inability to empty the bladder or incomplete emptying of the bladder) and incontinence (uncontrollable, involuntary leaking of urine) are both possible symptoms of disease of the autonomic nervous system. Which part of the autonomic division would be affected in each case? Explain your answer.

Answer: Sympathetic stimulation relaxes the muscles of the bladder wall, so overstimulation of the sympathetic division may cause urinary retention as the bladder muscles would not constrict enough to push out all the urine. The opposite would be true of incontinence. Overstimulation of the parasympathetic division could mean that the bladder muscles contract pushing urine out of the bladder.

- 3 If the dorsal root of a spinal nerve were damaged, would there be any impairment of the autonomic functions controlled by that nerve?

Answer: No, there would be no impairment as the dorsal root carries sensory nerves only, and the autonomic nervous system controls activity in the body through action of motor nerves that exit from the ventral root of the spinal cord.

- 4 If a drug stimulated acetylcholine receptors, would it affect the autonomic division, the somatic division or both? Give reasons for your answer.

Answer: It would affect both autonomic and somatic divisions because both use acetylcholine as the neurotransmitter that allows impulses to travel from axons to effectors, such as skeletal muscle or heart muscle.

- 5 The drug atropine occupies acetylcholine receptors at the synapse. Ophthalmologists once used atropine when they needed to dilate a patient's pupils. Explain why atropine would have this effect.

Answer: Atropine blocks the effects of acetylcholine, so that when placed in the eye, muscles in the eye cannot be stimulated to contract. Muscles in the iris relax and the pupil dilates. Muscles controlling the shape of the lens also relax.

- 6 Figure 4.4 shows a person's reaction to extreme fear. Describe the nervous and hormonal changes that would be taking place in the woman's body at the time the photograph was taken (you may need to refer to Chapter 2).

Answer:

- Nervous changes: sympathetic stimulation would become dominant preparing the body for increased activity (fight-or-flight).
- Hormonal changes: sympathetic stimulation would cause the adrenal medulla to release the hormones adrenaline and noradrenaline. These hormones would intensify the fight-or-flight responses brought about by sympathetic nervous stimulation.