

SUGGESTED TEXTBOOK ANSWERS

Chapter 6 Detecting and regulating change

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

Science inquiry

Activity 6.1 Reflexes

I The knee reflex

- 1 Describe the response that occurs.

Answer: The knee should jerk. That is, the lower limb should kick upwards.

- 2 Describe the location of the muscle or muscles that produce the response.

Answer: The muscle group that produces the response is the quadriceps. It is located at the front of the thigh and it is the extensor muscle of the knee.

- 3 Describe, in words, the reflex arc that is involved in the response.

Answer: The stimulus is the stretching of the patellar tendon when it is struck below the knee cap. This causes stretch receptors on the tendon to send nerve impulses, via the sensory neuron to the spinal cord. An interneuron transmits the impulse to a motor neuron, which then carries the message to the thigh muscle. The muscle is stimulated to contract, thus causing the knee to extend. (In the patellar reflex the sensory neuron synapses directly with the motor neuron. There is no interneuron, but students could not be expected to know that).

- 4 Does the response seem to be stronger at any particular angle of flexion? If so, can you suggest an explanation?

Answer: This will vary with the individual, and will probably depend on how much tension there is in the patellar tendon.

II The heel reflex

- 5 Describe the response.

Answer: The response is a contraction of the calf muscles, which results in a slight extension (straightening) of the foot. This is known as the ankle jerk reflex or the Achilles reflex.

- 6 What is the stimulus in this case?

Answer: Stretching of the (Achilles) tendon when struck with a ruler

- 7 In what ways is the heel reflex similar to the knee reflex?

Answer: In both cases the stimulus is the stretching of a tendon, and the response is contraction of a muscle.

8 Doctors often test reflexes such as the knee and heel reflex. What do you think testing such reflexes would tell a doctor?

Answer: Testing reflexes can determine whether the spinal cord is functioning or damaged at various levels; whether there is normal transmission of impulses along nerve fibres; or whether transmission of impulses at synapses is occurring normally. The tests may also be used to diagnose muscle problems.

III The eye reflex

9 Describe any response observed.

Answer: Blinking will occur.

10 Is the response a natural or a learned response?

Answer: Natural

11 Does the response have a purpose? Explain.

Answer: It is a reflex for the protection of the eye against entry of foreign objects.

IV The swallowing reflex

12 Describe the response that occurs.

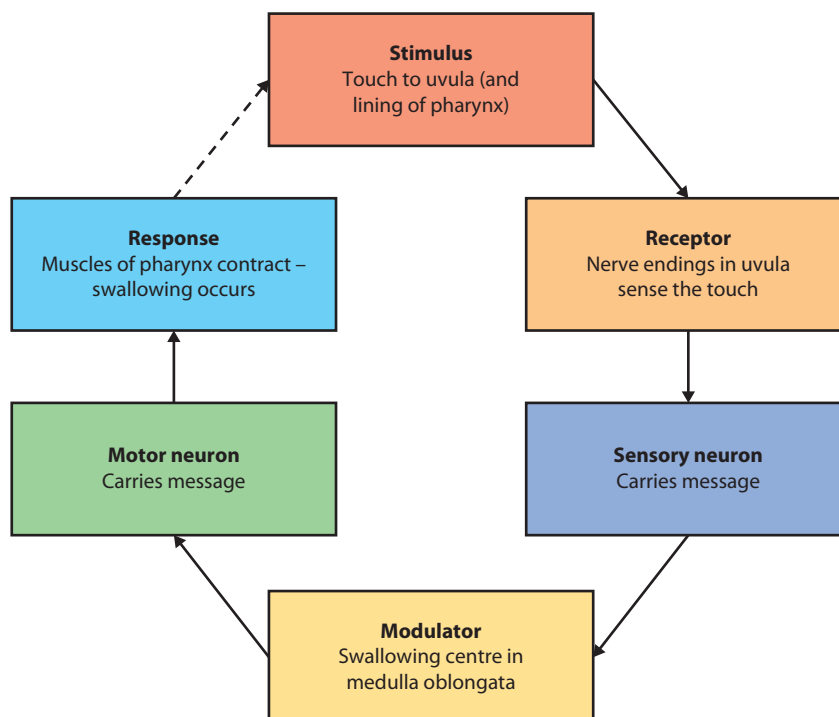
Answer: The person swallows.

13 How does this reflex aid swallowing?

Answer: When food is pushed by the tongue to the back of the throat it pushes the uvula, and this helps to initiate the swallowing reflex.

14 Draw and label a diagram showing the reflex arc that is involved in the swallowing reflex.

Answer:



V Cardiac sphincter reflex

15 Describe the sound you hear a few seconds after the water is swallowed.

Answer: A 'slushing' or gurgling sound. The sound is caused by water entering the stomach after the relaxation of the sphincter muscle.

16 What stimulus causes the cardiac sphincter to relax?

Answer: The touching/distension/stimulation of the lower part of the oesophagus causes a reflex relaxation of the smooth muscle that forms the cardiac sphincter.

Conclusions

17 Do all of the reflexes that you have investigated have the four important properties that were described in this chapter?

Answer: Yes, they should have. They all require a stimulus and are all involuntary, rapid and occur in the same way each time (stereotyped).

18 Write a brief statement summarising the importance of reflexes to the normal functioning of the human body.

Answer: A reflex is a rapid, automatic response to a change in the external or internal environment. Reflexes are one of the ways in which the body achieves homeostasis. Many reflexes are protective, like the blink reflex that protects the eye from foreign objects that may enter the eye, or the reflex that causes a limb to be withdrawn from a painful stimulus.

Activity 6.2 Reaction time

Design and carry out an investigation into reaction time. Some ideas are presented below but you may decide to do something quite different. (Reaction timers are available on the Internet. Use a search engine to search for 'reaction timer'. Some sites time reactions directly, some allow you to download freeware and some give directions for making reaction timers. Sites that time reactions will not be suitable for many of the suggestions below.)

Answer: Responses will depend on the variable being investigated. This activity could form the basis of an open investigation assessment.

Activity 6.3 More reaction times

1 Describe the pathway taken by the nerve impulses involved in detecting the stimulus and making the response.

Answer: In these online tests the pathway taken by the nerve impulses would be:

Stimulus received at the receptor (the eye); impulses carried by sensory nerve fibres (optic nerve) to cerebrum; impulses transferred to interneuron/s; interneuron carries impulses to motor nerve; motor nerves takes impulses to muscles of hand/arm; impulses causes muscles to contract.

2 Is the response an innate or an acquired response?

Answer: An acquired response

3 Draw a column graph showing your reaction time for five trials.

Answer: Student answers will vary. The five trials will be on the x axis and reaction time will be on the y axis.

4 Does your reaction time decrease with practice? If so, suggest why.

Answer: Most subjects find that they improve with practice. This could be because of:

- increased familiarity with the stimulus
- learning to respond to the stimulus
- establishing a pathway for the nerve impulses to travel.

5 Do five trials with your left hand and then five trials with your right. Describe and explain any difference between the two sets of trials.

Answer: For a simple response like clicking a mouse or striking a key on the computer keyboard there is likely to be little difference between the two hands.

For responses requiring more motor coordination the dominant hand is likely to be faster.

Review questions

1 In what parts of the body are thermoreceptors found?

Answer: Thermoreceptors are found in:

- the skin where they detect changes in the environmental temperature
- the hypothalamus where they detect the temperature of the blood flowing through the brain.

2 What does it mean when we say that receptors adapt to a stimulus?

Answer: When receptors adapt to a stimulus they no longer respond to that stimulus. For example, if touch receptors in the skin are stimulated constantly, they will cease sending off nerve impulses in response to the touch.

3 What are the characteristics of a reflex?

Answer: All reflexes have four important properties:

- Reflexes are triggered by a stimulus – they do not happen spontaneously.
- Reflexes are involuntary – they occur without any conscious thought.
- Reflex responses are rapid because only a small number of neurons are involved.
- Reflex responses are stereotyped – the response to a particular stimulus is always the same.

4 Draw a diagram showing the components of a reflex arc. Fully label your diagram.

Answer: Figure 6.2 on page 74 shows the components in a simple spinal reflex involving three neurons. Students' diagrams should include the following:

- A receptor
- A sensory neuron carrying impulses from the receptor to the central nervous system
- At least one synapse. (The nerve impulse may be passed directly to a motor neuron, or there may be one or more interneurons, which direct the impulse to the correct motor neuron.)
- A motor neuron carrying the nerve impulse to an effector
- An effector that carries out the appropriate response

5 a What is homeostasis?

Answer: Homeostasis is the maintenance of a constant environment inside the body.

b What are the aspects of the internal environment that need to be regulated?

Answer: The following aspects of the internal environment need to be regulated:

- Internal body temperature
- pH of body fluids
- Concentration of substances dissolved in the body fluids
- Concentration of glucose in the blood
- Concentration of oxygen and carbon dioxide in the body fluids, including the blood
- Blood pressure
- Concentration of metabolic wastes in the body fluids.

6 Define 'tolerance limits'.

Answer: Homeostasis aims to keep the internal environment constant but variations do occur. Tolerance limits are the upper and lower limits for factors in the internal environment. Above or below these limits the body cannot function normally.

7 Explain what the following terms mean:

a dynamic equilibrium

Answer: Dynamic equilibrium is the fluctuation of internal environmental factors around the normal level.

b set point.

Answer: The set point is the point around which internal environmental factors fluctuate.

8 Why is the stimulus-response-feedback mechanism referred to as a model?

Answer: A model, in scientific terms, is a simple way of representing a complex idea. The stimulus-response-feedback model describes in a simple way how homeostasis is achieved.

9 a Using examples, explain the difference between positive and negative feedback.

Answer: When the response to a stimulus has the effect of reducing or eliminating the stimulus it is known as negative feedback. For example, if you feel thirsty you have a drink. Your response, drinking, reduces the original stimulus of thirst.

Positive feedback is where the response to a stimulus reinforces and intensifies the stimulus. The intensified stimulus results in an even greater response, and so the response keeps on getting greater and greater.

An example of positive feedback occurs during childbirth when contractions of the uterus push the baby's head against the mother's cervix. This stimulation of the cervix causes the uterus to contract more strongly and the baby's head is pushed even more forcibly against the cervix. Uterine contractions become even more intense and so the process continues.

- b Why would a positive feedback loop be unable to achieve homeostasis?

Answer: Homeostasis aims to achieve a steady state inside the body. Positive feedback continually intensifies a response, so that the response gets stronger and stronger. In such a situation, a steady state could not be achieved.

Apply your knowledge

- 1 Many reflexes are protective. List five protective reflexes.

Answer: Protective reflexes include:

- blinking to protect the eye
- sneezing to remove irritants from the nasal cavity
- coughing to remove particles from the respiratory tract
- vomiting to remove irritating substances from the stomach
- constriction of the pupil to protect the retina from bright light
- withdrawal of a limb from a painful stimulus
- closing of the epiglottis when swallowing to prevent food and drink entering the trachea.

Students may be able to think of other valid examples.

- 2 Explain how we are able to distinguish between a light touch and heavy pressure on the skin.

Answer: We are able to differentiate between these two stimuli because they are detected by different receptors. A light touch stimulates touch receptors that are close to the surface of the skin and send messages to the brain so that we become aware of the light touch. Heavy pressure stimulates receptors much deeper in the skin and these make us consciously aware of the heavy pressure.

- 3 A driver approaching traffic lights saw the lights change from green to amber. She transferred her foot from the accelerator to the brake in order to stop. Describe the pathways of the nerve impulses that would be involved in this response.

Answer: The photoreceptors in the eye (retina) send impulses to the sensory area of the cerebral cortex. The driver has learned that amber means prepare to stop so impulses are then sent to the motor area of the cortex. The motor area sends impulses through motor neurons to the muscles of the leg and foot. When the impulses reach the muscles they cause contraction, so that the foot is moved from the accelerator to the brake.

- 4 A person stepped on a broken bottle and by a reflex response withdrew their foot from the painful stimulus. Assume that the distance from the person's foot to the spinal cord was 1.2 m. Using the figures for speed of transmission of nerve impulses quoted in Chapter 3 (on page 40), what is the shortest time (in milliseconds) that could have elapsed between the stimulus and the response (1000 ms = 1 s)?

Answer: Maximum speed of conduction quoted in Chapter 3 is 140 m/second, which is 0.14 m/millisecond.

$$1.2/0.14 = 8.57 \text{ milliseconds}$$

- 5 Is the situation described in Question 4 an example of a feedback system? Explain your answer.

Answer: The situation described is an example of feedback because withdrawal of the foot removes it from the stimulus that caused the initial pain. There will still be pain because of the damage to the skin but the original stimulus will no longer be present.

- 6 When you withdraw your hand from a painful stimulus, the response occurs before you become consciously aware that you have hurt yourself. Explain how this is possible.

Answer: Withdrawing the hand from a painful stimulus is a reflex action. The response would be coordinated by the spinal cord. When the nerve impulses enter the spinal cord from pain receptors in the hand, they are passed to motor neurons at the same level in the cord. The motor neurons carry the impulses to the arm muscles causing contraction and withdrawal of the hand.

At the same time messages are transmitted to the brain so that the person will become consciously aware of what is happening. However, the pathways to the brain involve many more synapses than those of the simple reflex, so that transmission of impulses is much slower. Thus the response may have actually occurred just before the person becomes consciously aware of it.

- 7 Why would it be unwise to continually take pain killers for a particular pain without seeking medical help?

Answer: Pain is an indication that tissues are being damaged. If the pain is continually masked by pain killers serious damage to tissues could be occurring.