## Chapter 12: Review Answers

**Student Textbook pages 432–433**

### Answers to Understanding Concepts Questions

**1.** The neural pathway from the organ of smell to the brain can be summarized by the following flowchart:

odour particles → bind to specific chemoreceptors called olfactory cells lining upper nasal cavity → ion channels in the cell membrane open → generates an action potential in the olfactory cells → directly linked to the olfactory bulb of the brain → the impulse is sent to emotional centres of the brain and the frontal lobe where the perception of odour occurs

**2.** Students' answers may contain the following:

| | What they detect | Example of human sense organ containing the receptor |
|---|---|---|
| Photoreceptors | visible light | eye (rods and cones) |
| Mechanoreceptors | sound waves | ear (hair cells in the organ of Corti) |
| | movement | ear (hair cells in the semicircular canals) |
| | touch/pressure/pain | skin (various sensory receptors) |
| Chemoreceptors | food molecules in saliva | tongue (taste buds) |
| | odours | nose (olfactory cells) |
| Thermoreceptors | heat and cold | skin (free nerve endings) |

**3. BLM 12.2.1A** can be used as the reference for this question.

| Label | Structure | Function |
|---|---|---|
| A | sclera | protects and supports the eyeball |
| B | choroid | absorbs stray light rays that are not detected by the photoreceptors and contains blood vessels that nourish the eye |
| C | iris | regulates amount of light entering the eye |
| D | pupil | provides opening for light to enter the inner eye |
| E | lens | bends and focusses light rays onto the fovea centralis |
| F | cornea | transparent part of the sclera that bends light rays into the eye |
| G | aqueous humour | maintains the shape of the cornea and provides oxygen and nutrients for the surrounding cells |
| H | ciliary muscle | changes the shape of the lens in order to focus |
| I | vitreous humour | maintains the shape of the eyeball and supports the surrounding cells |
| J | retina | contains the photoreceptors for sight |
| K | fovea centralis | provides for acute vision because it contains a high density of cones |
| L | optic nerve | receives impulses from the photoreceptors (rods and cones) and transmits sensory information from the eye to the brain |

Rods and cones are located within the retina. Their function is to act as photoreceptors for light energy: the rods for black and white vision in dim light; and the cones for colour vision in bright light.

**4.** Touch receptors in the skin transduce energy in the following manner:

light touch or pressure stimulates a mechanoreceptor → receptor depolarizes, converting energy of stimulus to electrochemical energy of nerve impulse → nerve impulse proceeds to spinal cord → impulse continues to the primary somatosensory cortex in the brain.

**5.** The nerve endings in the body are connected to the brain through the spinal cord. Sensory information from each part of the body (e.g., hand, arm, face, etc.) is directed to specific areas of the brain stem, thalamus, and cerebral cortex. When the area of the brain assigned to the lost limb no longer receives sensory input from the area, it begins to react to sensory input arriving at adjoining areas in the brain. In other words, the idle area overhears nearby impulses that are being processed and acts upon them in error.

**6.** Most humans can hear frequencies only between 20 and 20 000 Hz. The hair cells of the organ of Corti are able to distinguish both the frequency (pitch) and amplitude (volume) of sound waves. Different areas of the organ of Corti are sensitive to different wave frequencies. High frequencies, such as the sound of a whistle, most strongly stimulate the hair cells closest to the oval window. Low frequencies, such as a low note played by a tuba, most strongly stimulate the hair cells farthest from the oval window. The amplitude of a sound wave is experienced as the intensity or volume of a sound. The louder the noise, the more the fluid within the cochlea puts pressure on the hair cells of the basilar membrane.

Sensory neurons in the ear send information through the auditory nerve to the brain stem, thalamus, and ultimately the temporal lobes of the cerebrum for processing. The brain can distinguish the frequency and amplitude of the sound.

7. This process is called sensory adaptation. Sensory adaptation is a decrease in sensitivity to a given stimulus which occurs as a result of prolonged exposure to that stimulus. A massive amount of sensory information coming from many neural pathways bombards the brain every second. The benefit of sensory adaptation is that, in some cases, the brain can filter out redundant, insignificant information.
8. The reflex is called light adaptation in the eye. In bright light the iris constricts, which shrinks the pupil to let in less light. In dim light, the iris dilates, which widens the pupil and lets in more light.
9. The retinas of the swift fox are dominated by photoreceptor cells called rods. While rods cannot detect colour or produce images as sharp as those of the cone cells that dominate human eyes, they are much more sensitive to and function better in low light.
10. The blind spot is the area of the retina that does not contain any photoreceptors (rods or cones). It is the location where the optic nerve and blood vessels enter and leave the eye. It is not usually noticeable because the adjacent photoreceptors, the visual information from the other eye, and the cerebral cortex fill in the hole in the field of vision.
11. photon of light energy from the moon at night → absorbed by rods → rhodopsin splits into retinal and opsin → stops release of inhibitory neurotransmitter → permits transmission of neural impulse to optic nerve → travels through the optic nerve fibres out of the back of the eye → travels to the cerebral cortex of the brain → creates a visual image
12. The primary visual cortex is located in the occipital lobe of the brain. This is the first area to receive nerve impulses that have passed along the optic nerve. Signals conveying colour information then go on to several nearby visual areas for further processing. For perception and recognition, signals are then sent to so-called "higher centres," where they interact with stored memories and input from other sensory and motor centres.
13. Even standing still is an exercise in dynamic equilibrium. Balance is maintained as a result of the interaction of three systems: the visual, the inner ear, and the proprioceptor systems.

    Vision plays a significant role in balance. Vision gives the person posing for a picture a sense of where they are in relation to other things around them. Even if a person is trying to stand perfectly still, he/she sways very slightly all the time to all four sides.

    The structures of the inner ear help us stand upright. The semicircular canals contain mechanoreceptors that detect head and body rotation (rotational equilibrium). The semicircular canals are three fluid-filled loops arranged in three different planes—one for each dimension of space. The base of each canal has a jelly-like covering called a cupula. The stereocilia of hair cells in the canals stick into the cupula, and when the body rotates, the fluid inside the semicircular canals moves and bends the stereocilia. These hair cells send rotational information to the brain.

    The balance required while moving the head forward and backward is called gravitational equilibrium. This equilibrium depends on the two structures called the utricle and saccule, which together make up the fluid-filled vestibule of the inner ear. Both structures contain calcium carbonate granules called otoliths. The otoliths lie in a cupula over a layer of hair cells. When the head dips forward or back, gravity pulls on the otoliths. This puts pressure on some of the hair cells, which send a neural impulse to the brain, indicating the head's position.

    Proprioceptors are found in muscles, tendons, and joints throughout the body and send information about body position to the brain. Balance is maintained by alternate contraction and relaxation of the leg muscles.
14. Students' diagrams should be similar to Figure 12.10 on page 412 of the student textbook. Accommodation occurs because the lens can change shape to focus images clearly on the retina. A change in shape allows for finer focus when viewing near and far objects. If an object is near, the ciliary muscles contract and the suspensory ligaments relax, causing the lens to become more rounded. If an object is far away, the ciliary muscles relax and the suspensory ligaments become taut, causing the lens to flatten.
15. Rotational equilibrium refers to head and body rotation. The semicircular canals contain mechanoreceptors that detect head and body rotation. The semicircular canals are three fluid-filled loops arranged in three different planes. The base of each canal has a jelly-like covering called a cupula covering the stereocilia of hair cells. When the body rotates, the fluid inside the semicircular canals moves and bends the stereocilia. The hair cells then send rotational information to the brain. A figure skater doing a spin would depend on these processes to maintain balance during a performance. The balance required while moving the head forward and backward is called gravitational equilibrium. This equilibrium depends on the two structures called the utricle and saccule, which together make up the fluid-filled vestibule of the inner ear. Both structures contain calcium carbonate granules called otoliths. The otoliths lie in a cupula over a layer of hair cells. When the head dips forward or back, gravity pulls on the otoliths. This puts pressure on some of the hair cells, which send a neural impulse to the brain, indicating the head's position. When someone nods, he/she uses gravitational equilibrium to maintain balance.
16. Rod cells are very efficient in low light and are the receptors primarily involved in night vision. Peripheral or side vision is what you see on the outermost edges of your field of view while you look straight ahead. The rods are the predominant photoreceptor involved in peripheral vision. Therefore, any disorder that affects the peripheral

vision is affecting the rods and therefore night vision, which would make driving at this time very dangerous.

**17.** The temporal lobe is dedicated to hearing, auditory perception, and the storage of memories. Students will likely state that an injury to this area of the brain will cause hearing and/or memory loss.

**18.** The pathway of sound can be illustrated by the following flowchart:

sound wave → (outer ear) pinna → auditory canal → (middle ear) tympanum → ossicles (malleus, incus, stapes) → oval window → pressure wave in fluid environment → (inner ear) cochlea → organ of Corti → basilar membrane → stereocilia → tectorial membrane → mechanoreceptors (hair cells) → nerve impulse → auditory nerve → temporal lobe of the brain for perception of sound.

The following chart summarizes the principal structures involved in hearing and their functions.

| Structure | Function |
|---|---|
| Outer Ear | |
| pinna | collects sound waves |
| auditory canal | filters air |
| Middle Ear | |
| tympanic membrane and ossicles | amplify sound waves |
| oval window | receives vibrations from the ossicles and passes them into the cochlea |
| Inner Ear | |
| organ of Corti | hair cells of the organ of Corti are able to distinguish both the frequency (pitch) and amplitude (intensity) of sound waves |
| basilar membrane | receives pressure waves and moves stereocilia |
| stereocilia | triggers hair cells to depolarize |
| tectorial membrane | receives movement of stereocilia |
| mechanoreceptors (hair cells) | detect movement of stereocilia and react by initiating nerve impulse |
| auditory nerve | transmits nerve impulse to brain |
| temporal lobe of brain | processes nerve impulses from ear to allow perception of sound |

**19.** Most humans can hear frequencies only between 20 and 20 000 Hz. Hair cells in different areas of the organ of Corti are sensitive to different wave frequencies. Repeated or sustained exposure to loud noise at certain frequencies will destroy the stereocilia that respond to that frequency of sound. The result is that the machine operator can no longer "hear" sounds within that frequency range.

## Answers to Applying Concepts Questions

**20.** Possible effects of sensory deprivation include extreme anxiety, hallucinations, bizarre thoughts, depression, and antisocial behaviour. We use our senses to determine where we are, what our bodies are doing, and what is happening around us, as well as to keep our bodies in a balanced state (homeostasis). Deprivation of stimuli from one or more of the senses can be disorienting because we are deprived of that information, and it can eventually lead to the more serious side effects mentioned.

**21.** Student designs should indicate that they are protecting the occipital lobe at the base of the skull.

**22.** Colour-blind individuals are actually colour *deficient*, as they lack or are deficient in particular cones, typically red or green. Thus a red-green colour-blind person may find it difficult or impossible to distinguish between these colours. Answers should reflect the knowledge that cones respond to different wavelengths of light and an understanding that technologies are designed to repair or replace the red or green cones.

**23.** Technologies such as eyeglasses and hearing aids can help compensate for loss of hearing or vision, but the user must always carry the artificial device. A successful implant to replace the damaged structure that could receive sound waves or light rays and transduce them into nerve impulses would be a more effective treatment.

**24.** The lens normally changes shape to focus images clearly on the retina in a process called accommodation. As people age, the aging of the cells in the lens causes the lens to become less flexible, which is one of the causes of lost accommodation. Glasses are one way to compensate for this lost reflex.

**25.** Olfaction, the act or process of smelling, is a dog's primary sense. A dog's sense of smell is said to be 1000 times more sensitive than that of humans. Some structural adaptations in a dog that give it a keener sense of smell than humans might include the following: more olfactory receptors in its nose than humans; structures to keep inhaled air (and odours) in the nasal cavity until odour molecules can interact with the olfactory cells; a more well-developed olfactory lobe; a lower level of stimulus required to create an action potential.

**26.** When students stare at the green bird for 1 min and then at the cage, they should see a pale red bird in the cage. When students stare at the red bird for 1 min and then at the cage, they should see a pale green bird. As the students stare at each bird, the photoreceptors (cones) for that colour become desensitized (or fatigued). Then, when the students look at a white or neutral background (the cage), their eyes "subtract" the colour that was fatigued, and they see its complementary colour.

**27.** Dogs are most likely to see blue-violet and yellow. They are likely unable to distinguish among green, orange, and red.

## Answers to Making Connections Questions

**28.** Sensory stimuli cause a depolarization of sensory receptor cell membranes. If the sensory stimulus is strong enough to depolarize the membrane to the threshold potential, an action potential is produced by the sensory receptor and is conducted to the CNS. If a sensory stimulus is strong enough to affect a number of receptors, more action potentials will be generated. The pain receptors in some individuals may require a higher level of stimulus before they generate an action potential. Students may also recognize that the sensory cortex of the brain is responsible for perceiving pain (intensity, location, and type of pain).

**29.** Students may suggest that the scent of vanilla reduces apnea in infants because odours are associated with the emotional centres of the brain and frontal lobe. A pleasant odour may therefore cause relaxation, which might improve the breathing rates of these infants.

**30.** One neurotoxin from rattlesnake venom blocks receptors on postsynaptic neurons. Venom from the female black widow spider stimulates exocytosis of synaptic vesicles from neurons. If a neurotoxin blocks receptors on postsynaptic neurons (as in the rattlesnake venom), it could prevent the binding of the neurotransmitter acetylcholine, thereby blocking the transmission of a nerve impulse to the muscle and causing muscle paralysis. If the impulse is a result of a negative stimulus, such as pain, blocking it could be effective in medical treatment. If a neurotoxin increases the release of neurotransmitters (as in the spider venom), it could also result in nerve and muscle fatigue and be useful in preventing transmission of pain impulses.

**31.** Students' answers will depend on a number of factors, including their personal values. Accept answers that are well thought-out, with reasoning that is justified.

**32.** Literally thousands of drugs prescribed by doctors are derived from plants and animals. If natural habitats are destroyed, we will not be able to use those plants nor discover new ones.

**`34.** There isn't a right or a wrong answer to the question of patenting and selling traditional knowledge of medications. Students will have a variety of opinions on this topic.