Answer Key
Sensation and Perception

1. **A—**Most of that refraction in the eye takes place at the air–cornea boundary, since the transition from the air into the cornea is the largest change in index of refraction. About 80% of the refraction occurs at the air–cornea boundary.

2. **C—**Olfactory impulses do not pass through the thalamus but project directly to the frontal lobe and the limbic system.

3. **D—**During a somatic reflex such as this, nerve signals travel from stretch receptors along afferent nerve fibers to the posterior horn of the spinal cord. (For a reflex governing a thigh muscle, the connections involved will be in the spinal cord. For certain impulses, the reflex arc occurs in the brainstem). The gray matter of the spinal cord comprises the integrating center where these interneurons are located. Efferent nerve fibers carry motor nerve signals to muscles.

4. **C—**Weber's law states that the change in a stimulus that will be just noticeable is a constant ratio of the original stimulus.

5. **A—**Visual capture is the dominance of vision over other sense modalities in creating a percept. In this process, the visual senses influence the other parts of the somatosensory system, to result in a perceived environment that is not congruent with the actual stimuli. Through this phenomenon, the visual system is able to disregard what other information a different sensory system is conveying and provide a logical explanation for whatever output the environment provides.

6. **C—**The gestalt principle of closure states that individuals perceive objects such as shapes, letters, pictures, etc. as being whole when they are not complete.

7. **B—** Top-down processing involves perception that is an active and constructive process. Additionally, top-down processing is an approach not directly given by stimulus input, but is the result of stimulus, internal hypotheses, and expectation interactions. When a stimulus is presented where clarity is uncertain, perception becomes a top-down approach.

8. **B—** The proximal stimulus is the pattern of energy actually falling the retina which changes as the viewing angle changes. However, your perception of the coin remains constant. The constancy of the perceptual response despite changes in the proximal stimulus is called perceptual constancy.

9. **C—** In signal detection theory, a trial in which-stimuli was absent and the observer categorized it as absent is coded as a correct rejection.

10. **D—**Young–Helmholtz theory is a theory of trichromatic color vision whose initial postulate, later validated, includes the existence of three types of photoreceptors in the eye, each of which is sensitive to a particular range of visible light (yellowish green, cyanish-green, and blue). Young-Helmholtz theory is also known as trichromatic theory. (When there are two equivalent answers in a multiple choice question, neither can be right!) Opponent-process theory suggests that color perception is controlled by the activity of three opponent systems. The theory postulates three independent receptor types which all have opposing pairs: white and black, blue and yellow, and red and green. These three pairs produce combinations of colors through the opponent process. Furthermore, according to this theory, for each of these three pairs, three types of chemicals in the retina occur, in which two types of chemical reactions exist. These reactions would yield one member of the pair in their building up phase, or anabolic process, whereas they would yield the other member while in a destructive phase, or a catabolic process. The colors in each pair

oppose each other. Red-green receptors cannot send messages about both colors at the same time. This theory also explains negative afterimages; once a stimulus of a certain color is presented, the opponent color is perceived after the stimulus is removed because the anabolic and catabolic processes are reversed.

11. A—With the exception of olfactory information, all sensory information reaches the cortex by way of the thalamus. In the case of the visual system, the thalamic nucleus is the lateral geniculate nucleus. The primary visual cortex within the occipital lobe is characterized by a unique layered appearance in Nissl stained tissue, which is why it is known as the striate cortex. The extrastriate cortex includes all of the occipital lobe areas surrounding the primary visual cortex. Information from the "color", "shape/form", "location" and "motion" detecting neurons in the striate cortex are sent to different areas of the extrastriate cortex for processing of many of the characteristics associated with higher order visual perception. In addition to the striate cortex and extrastriate cortex involved in visual processing, there is also the visual association cortex. The visual association cortex includes much of the posterior temporal lobes and adjacent areas of the parietal lobe. (Most of the caudal half of the brain is involved in visual processing). In other words, taking the visual association cortex into account, "occipital lobe" is not a complete answer, but it is the best answer of the choices.

12. D—The olfactory bulb receives sensory input from axons from olfactory receptor neurons of the olfactory epithelium. The olfactory bulb is part of the limbic system, sending olfactory information to be further processed in the amygdala, the orbitofrontal cortex (OFC) and the hippocampus where it plays a role in emotion, memory and learning.

13. B—If the trichromatic theory were the only way to explain color processing, then red-green colorblind people would also be unable to see yellow (as red/green cones work simultaneously to create yellow). However, ganglion cells contribute to our color experience. Activation of a ganglion cell exciting blue and inhibits the opposing color yellow. When the ganglion cell does not receive blue information, blue is inhibited and yellow is excited.

14. C—The vestibular system consists of the otolith organs and the semicircular canals. Illusions in aviation, such as described in the question, are caused when the brain cannot reconcile the vestibular and visual inputs. The three semicircular canals, recognizing accelerations in pitch, yaw, and roll, are stimulated by angular accelerations. The otolith organs, the saccule and utricle, are stimulated by linear accelerations. Stimulation of the semicircular canals occurs when movement of the endolymph inside the canals causes movement of the crista ampullaris and the hair cells within them. Stimulation of the otolith organs occurs when gravitational forces or linear accelerations cause movement of the otolith membrane, the otoliths, and the hair cells of the macula.

15. A—The blind spot is the place in the visual field that corresponds to the lack of light-detecting photoreceptor cells on the optic disc of the retina where the optic nerve passes through the optic disc. Because there are no cells to detect light on the optic disc, the corresponding part of the field of vision is invisible.

16. B—In the phi phenomenon, motion is described as having direction but to not be bound to an object. This observation led early researchers to suggest that the perception of motion is a primary sense.

17. C—The oval window is a membrane-covered opening that leads from the middle ear to the vestibule of the inner ear. Vibrations that contact the tympanic membrane travel through the three ossicles and into the inner ear. The oval window is the intersection of the middle ear

with the inner ear and is directly contacted by the stapes.

18. A—In signal detection theory, absolute threshold is defined as the level at which a stimulus will be detected a specified percentage (usually 50%) of the time.

19. A—Intensity measures the actual energy flux produced by a sound source in watts per square meter. The loudness scale is related to intensity, but it is based on how humans perceive sound, and is proportional to the logarithm of intensity.

$$\beta = 10 \log \left(\frac{I}{I_0}\right)$$

If I_1 is the original intensity, doubling the number of amplifiers will produce a new intensity of $2I_1$. The decibel level with this new intensity will be:

$$\beta_2 = 10 \log \left(\frac{2I_1}{I_0}\right) = 10\left[\log \left(\frac{I_1}{I_0}\right) + \log 2\right]$$

Doubling the intensity results in the addition of 10 log (2) decibels, or about 3 decibels.

(If you don't remember that the common logarithm of 2 is about 0.3, then ask yourself, to what power do I need to raise 10 to get 2? Well, 2 is a bit less than the cube root of 10, so the logarithm of 2 is a bit less than one third.)

20. C—Volley theory states that groups of neurons of the auditory system respond to a sound by firing action potentials slightly out of phase with one another so that when combined, a greater frequency of sound can be encoded and sent to the brain to be analyzed. The theory is a supplement to the frequency theory of hearing. It was later discovered that this only occurs in response to sounds that are about 500 Hz to 5000 Hz.

21. D—Although contributing to movement sense, the hair cells of the semicircular canals and the otolith organs of the vestibule are not proprioceptors. The brain integrates information from proprioception and from the vestibular system into its overall sense of body position, movement, and acceleration.

22. D—Muscle spindles in striated muscle, Golgi tendon organs, and Pacinian and Ruffini's corpuscles, found in joint capsules, are all proprioceptors.

23. C—Nociceptors are pain receptors. Mechanical nociceptors respond to excess pressure or mechanical deformation such as incisions that break the skin surface.

24. A—A thermoreceptor is a non-specialised sensory receptor, or more accurately the receptive portion of a sensory neuron, that codes absolute and relative changes in temperature, primarily within the innocuous range. The adequate stimulus for a warm receptor is warming, which results in an increase in their action potential discharge rate. Cooling results in a decrease in warm receptor discharge rate. For cold receptors their firing rate increases during cooling and decreases during warming.

25. B—Activation of rods and cones is actually hyperpolarization. When they are not being stimulated, they depolarize and release glutamate continuously.

26. A—The rhodopsin or iodopsin in the disc membrane of the outer segment or a rod or a code absorbs a photon, changing the configuration of a retinal cofactor inside the protein from the cis-form to the trans-form. This event triggers rhodopsin to activate transducin. This is the first amplification step – each photoactivated rhodopsin triggers activation of about 100 transducins. Each transducin then activates the enzyme cGMP-specific phosphodiesterase (PDE). PDE then catalyzes the hydrolysis of cGMP to 5' GMP. This is the second amplification step, where a single PDE hydrolyses about 1000 cGMP molecules. The net concentration

of intracellular cGMP is reduced, resulting in the closure of cyclic nucleotide-gated Na+ ion channels located in the photoreceptor outer segment membrane. As a result, sodium ions can no longer enter the cell, and the photoreceptor outer segment membrane becomes hyperpolarized.

27. C—Rhodopsin is a G-protein coupled receptor. Transducin is the heterotrimeric G-protein associated with rhodopsin, having an α subunit which dissociates from the $\beta\gamma$ subunits in response to a conformational change in rhodopsin caused by the absorption of a photon by the rhodopsin moiety retinal. Activated transducin α-subunit activates cGMP phosphodiesterase.

28. D—Merkel cells and Meissner's corpuscles are both essential for light touch sensation. Pacinian corpuscles are responsible for sensitivity to vibration and pressure, responding only to sudden disturbances and are especially sensitive to vibration. Ruffini's corpuscles are sensitive to skin stretch, and contributes to the kinesthetic sense of and control of finger position and movement. Ruffini's corpuscles also act as thermoreceptors. Free nerve endings are nociceptors, detecting pain.

29. A—The choroid, also known as the choroidea or choroid coat, is the vascular layer of the eye, containing connective tissue, and lying between the retina and the sclera.

30. C—Melanin a dark colured pigment, helps the choroid limit uncontrolled reflection within the eye that would potentially result in the perception of confusing images. In albino humans, frequently melanin is absent and vision is low.

31. C—In myopia the eyeball is usually too long from front to back. This causes light rays to focus at a point in front of the retina, rather than directly on its surface. This makes distant objects blurry. Myopia can also be the result of a cornea that is too curved for the length of the eyeball or a lens that is too thick. For some people, their myopia may be caused by a combination of problems in the cornea, lens, and length of the eyeball.

32. B—The organ of Corti is located in the cochlea of the inner ear between the vestibular duct and the tympanic duct.

33. D—Special sense receptors are structurally more complex than general sense receptors and localized in special sense organs. General sense receptors are scattered throughout the body. Balance, provided by the vestibule, hearing and smell are special senses. Proprioception is a general sense. Proprioceptors include muscle spindles in striated muscles and tendons (Golgi tendon organ) and receptors in the fibrous capsules in joints.

34. D—The process of perception begins with an object in the real world, termed the distal stimulus or distal object. The proximal stimulus is generally defined as the pattern of energy impinging on the observer's sensory receptors. These neural signals are transmitted to the brain and processed. The resulting mental re-creation of the distal stimulus is the percept.

35. B—The refractive power of the eye in myopia (nearsightedness) is too great for the distance from the cornea to the retina. The focussed image of far objects is located in front of the retina not upon it. Therefore, the prescription for myopia is a diverging lens. A diverging lens has a negative strength in diopters because it has a negative focal length. The strength of a lens in diopters is the reciprocal of the focal length (in meters).

36. B—The posterior chamber is a narrow space behind the peripheral part of the iris, and in front of the suspensory ligament of the lens and the ciliary processes. This name is easy to confuse with the vitreous chamber, which is even more posterior (on the other side of the lens).

37. C— Activation of a photoreceptor cell is a hy-

perpolarization (inhibition) of the cell. When they are not being stimulated, such as in the dark, rod cells and cone cells depolarize and release a neurotransmitter (glutamate) spontaneously.

38. A—The order of neuronal processing of necessary structures in the auditory pathway is: cochlear nucleus, inferior colliculus, medial geniculate nucleus (part of the thalamic relay system), and finally left posterior superior temporal gyrus (primary audtitory cortex). Some tracts route through the superior olivary complex of the pons on the way from the cochlear nucleus to the inferior colliculus.

39. C—The spinothalamic tract uses three neurons to convey sensory information from the periphery to conscious level at the cerebral cortex. Pseudounipolar neurons in the dorsal root ganglion have axons that lead from the skin into the dorsal spinal cord where they ascend or descend one or two vertebral levels then synapse with secondary neurons called tract cells. The axons of the tract cells cross over (decussate) to the other side of the spinal cord then travel up the length of the spinal cord into the brainstem, specifically the rostral ventromedial medulla. The neurons ultimately synapse with third-order neurons in several nuclei of the thalamus. From there, signals go to the primary somatosensory cortex.

40. A—Gibson and Walk hypothesized that depth perception is at least partly inherent as opposed to a completely learned process. To test this, they placed 36 infants, 6 to 14 months of age, on the shallow side of the visual cliff apparatus. Once the infant was placed on the opaque end of the platform, the caregivers (typically a parent) stood on the other side of the transparent plexiglas, calling out for them to come or holding some sort of enticing stimulus such as a toy so that the infant would be motivated to crawl across towards them. It was assumed if the child was reluctant to crawl to their caregiver, he or she was able to perceive depth, believing that the transparent space was an actual cliff. The researchers found that 27 of the infants crawled over to their mother on the "deep" side without any problems. A few of the infants crawled but were extremely hesitant. Some infants refused to crawl because they were confused about the perceived drop between them and their mothers. The infants knew the glass was solid by patting it, but still did not cross. In this experiment, all of the babies relied on their vision in order to navigate across the apparatus. This shows that when healthy infants are able to crawl, they can perceive depth.

41. D—An illusion refers to a misperception. This denotes an instance where the individual takes something for something else. This is in contrast to a hallucination. The key characteristic is that in hallucinations there are no external stimuli.

42. D—Because of stereopsis the two eyeballs focus on the same object. In doing so they converge. The convergence will stretch the extraocular muscles. As happens with the monocular accommodation cue, kinesthetic sensations from these extraocular muscles also help in depth/distance perception.

43. C—Bending the stereocilia in a certain direction depolarizes the cell and results in increased afferent activity. Bending the stereocilia in the opposite direction hyperpolarizes the cell and results in a decrease in afferent activity.

44. A—In accomodation for near objects the ciliary muscle contracts, pulling itself forward and releasing the tension on the lens caused by the zonular fibers. This release of tension of the zonular fibers causes the lens to become more spherical, adapting to short range focus. Conversely, relaxation of the ciliary muscle causes the zonular fibers to become taut, flattening the lens, increasing the focal distance for long range focus.

45. C—Gate control theory explains how stimu-

lus that activates only nonnociceptive nerves can inhibit pain, such as rubbing the area of a wound. The pain seems to be lessened when the area is rubbed because activation of nonnociceptive fibers inhibits the firing of nociceptive ones in the spinal cord lamina.

46. A—In developing signal detection theory, Green and Swets (1966) were not only interested in determining how we detect stimuli under uncertain conditions, they were also interested in response biases. Response bias in a signal detection trial is revealed in the tendency to make one type of guess over another when the subject is in doubt. In the experient, sometimes a sound is presented sometimes not. The frequency of false alarms and misses helps measure how biased a subject is for responding "yes" or "no" in general.

47. C—Speech perception is multimodal, which means that it involves information from more than one sensory modality, in particular, audition and vision.

48. A— About 90% of the axons in the optic nerve go to the lateral geniculate nucleus in the thalamus. Another population sends information to the superior colliculus in the midbrain, which assists in controlling eye movements as well as other motor responses. The general function of the superior colliculus is to direct behavioral responses toward specific points in body-centered space. The superior colliculus is also involved in generating spatially directed head turns, arm-reaching movements and shifts in attention that do not involve any overt movements. A study in 2004 (Cavenaugh, Wurzt) demonstrated that if the superior colliculus of a monkey's brain is electrically stimulated, there is be a significant decrease in reaction time to detect a visual change.

49. A— Visual agnosia is a deficit in perceiving objects. It is not due to a deficit in vision (acuity, visual field, and scanning), language, memory, or low intellect. While cortical blindness results from lesions to primary visual cortex (striate cortex), visual agnosia is often due to damage to more anterior cortex such as the posterior occipital and/or temporal lobes in the brain.

50. B— Taste buds contain the taste receptor cells, which are also known as gustatory cells. The taste receptors are located around the small structures known as papillae found on the upper surface of the tongue, soft palate, upper esophagus, the cheek and epiglottis.