Question 1: Following a bicycle accident, you are disturbed to find that you are unable to see anything in the left visual field. Where has the retinofugal pathway been damaged?

Answer: Lesions anywhere in the retinofugal projection from the eye to the lateral geniculate nucleus (LGN) to the visual cortex may cause specific visual deficits depending on the site of the lesion. The bicycle accident has resulted in a transection of the right optic *tract*, resulting in blindness in the left visual field as viewed through either eye. Axons from the nasal retina of the left eye and temporal retinal of the right eye have been damaged. In contrast, a transaction of the right optic *nerve* would render a person blind in the right eye because both nasal and temporal axons originating from the right eye would be damaged; none of the axons in the optic nerve have crossed to the opposite side of the brain. Crossing, or decussation, occurs at the optic chiasm, which lies between the optic nerve and the optic tract.

Question 2: What part of the visual field is represented in the left LGN?

Answer: The left LGN receives retinal information about the right visual field. Left LGN neurons receive synaptic input from the retinal ganglion cells in the nasal half of the right retina and the temporal half of the left retina. In the left LGN, the left eye (ipsilateral) axons synapse on cells in layers 2, 3, and 5 and the right (contralateral) eye axons synapse on cells in layers 1, 4, and 6.

Question 3: A worm has eaten part of one lateral geniculate nucleus. You can no longer perceive color in the right visual field of the right eye. What layer(s) of which LGN is damaged?

Answer: The worm has eaten koniocellular neurons in the left LGN, and perhaps some parvocellular neurons receiving contralateral retinal projections. In addition to neurons in the

six principal layers of the LGN (layers 1–6), there are numerous tiny neurons on the ventral side of each of the six principle layers called koniocellular layers. The cells in the koniocellular layers receive inputs from the nonM-nonP types of retinal ganglion cells and have center-surround receptive fields that are either light-dark or color-opponent. If you cannot perceive color in the right visual field, it means that the color-opponent koniocellular layers of the left LGN are damaged. Some parvocellular neurons also exhibit color opponency.

Question 4: List the chain of connections that link a cone in the retina to a blob cell in striate cortex.

Answer: There are three parallel pathways: magnocellular, parvocellular, and koniocellular that connect the retina to the striate cortex, but only the parvocellular and koniocellular pathways receive input from cones and are sensitive to differences in wavelength. The parvocellular pathway begins with P-type ganglion cells of the retina that project axons to the parvocellular layers of the LGN; these LGN neurons project to layer IVCβ of the striate cortex, which in turn project to blob neurons. The koniocellular pathway begins with nonM-nonP ganglion cells. These ganglion cells project axons to the koniocellular layers in the LGN that, in turn, project to the blob neurons in layers II and III of striate cortex.

Question 5: How are receptive fields transformed at each of the synaptic relays that connect an M-type retinal ganglion cell to a neuron in the striate cortical layer IVB?

Answer: The **magnocellular pathway** begins with M-type ganglion cells of the retina with large, monocular, center-surround receptive fields. These cells project to the magnocellular layers of the LGN that also have large, monocular, center-surround receptive fields. The

magnocellular LGN layers project to layer IVCα of the striate cortex where the monocular, center-surround receptive field properties are retained. Finally, neurons in layer IVCα project to the layer IVB. The pyramidal cells in the layer IVB have binocular receptive fields that are elongated rather than circular. These receptive fields can be either simple or complex. Many of them are orientation-selective and direction-selective, but not wavelength-sensitive.

Question 6: Which pathway, magnocellular or parvocellular, provides a greater percentage of the input to the striate cortex? What are the two analyses of the visual world that are involved with these pathways?

Answer: The parvocellular pathway provides the greatest percentage of input to the striate cortex. This pathway contains neurons with sustained responses, small receptive fields, and fewer direction selective neurons. It originates with P-type retinal ganglion cells that project to parvocellular LGN neurons, which in turn project to layer IVCβ in striate cortex. This pathway is thought to be involved in the analysis of object shape. The magnocellular pathway contains neurons with transient responses, large receptive fields, and the highest percentage of direction-sensitive neurons. It originates with M-type retinal ganglion cells that project to magnocellular LGN cells, which in turn project to layer IVCα of striate cortex. This pathway is thought to be involved in the analysis of object motion and the guidance of motor actions.

Question 7: What is parallel processing in the visual system? Give two examples.

Answer: There are separate, parallel channels or pathways from retinal to cortex that process different facets of the visual scene. They use different subsets of neurons and have distinctive receptive field properties. For example, the parvocellular-interblob pathway

analyzes object shape and the magnocellular pathway analyzes object motion. These pathways are "parallel" because they use different retinal, LGN, and cortical neurons in their retinofugal projections. They possess distinctive receptive field properties (e.g., large vs. small, transient vs. sustained) in all three locations. Other examples of parallel pathways include the blob pathway specialized for object color, and the inputs from the two eyes, which remain segregated until inputs from the two eyes converge in the superficial layers of the striate cortex.

Question 8: If a child is born cross-eyed and the condition is not corrected before the age of 10, binocular depth perception will be lost forever. This is explained by a modification in the circuitry of the visual system. Based on your knowledge of the central visual system, where do you think the circuitry is modified?

Answer: The noncorresponding input from the two, misaligned eyes prevents the formation of binocular neurons in striate cortex or any extrastriate visual area.

Question 9: In what ways is area MT more specialized for the detection of visual motion than area V1?

Answer: Neurons in area MT have large receptive fields that respond to stimulus movement in a narrow range of directions. Almost all cells are direction-selective, and many respond to specific types of motion, such as drifting spots of light. The organization of area MT reveals a specialization for motion processing—direction-of-motion columns that are analogous to the orientation columns in area V1. The direction-of-motion columns facilitate a comparison of the activity across columns spanning a range of 360^{o} of preferred directions.

Question 10: For many years, it was thought that depth perception involved the recognition of objects in each eye separately followed by binocular integration. How do the stereograms discussed in Box 10.4 disprove this hypothesis? What areas of the brain are possible sites for binocular integration?

Answer: The stereograms are created by two sets of randomly spaced dots. Some of the dots shown to one eye (such as those within a smaller square) are shifted horizontally relative to the dots shown to the other eye. The visual system interprets this shift as a difference in the vantage points for the two eyes, so the resulting image is seen in three dimensions. This would not be possible if it was necessary to first perceive the square and then perceive it in three-dimensional depth. Potential sites of binocular interaction include the superficial layers of the striate cortex and the extrastriate visual areas to which they project.