Question 1: List the components of the lateral and ventromedial descending spinal pathways. Which type of movement does each path control?

Answer: The components of the lateral descending spinal pathways are the corticospinal tract and the rubrospinal tract. The components of the ventromedial descending spinal pathways are the vestibulospinal tract, the tectospinal tract, the pontine reticulospinal tract, and the medullary reticulospinal tract. The lateral pathways are involved in the voluntary movement of the distal musculature. The lateral pathways control the fine movements of arms and fingers. The ventromedial pathways control the posture of the head and neck.

Question 2: You are a neurologist presented with a patient who has the following symptom: an inability to independently wiggle the toes on the left foot, but with all other movements (walking, independent finger movement) apparently intact. You suspect a lesion in the spinal cord. Where?

Answer: Lesions in the descending motor tracts, which originate in the upper motor system, can cause an abnormal Babinski sign. This was described by French neurologist Joseph Babinski in 1896. Scratching the sole of the foot from the heel toward the toes causes reflexive upward flexion of the big toe and an outward fanning of other toes. The normal response to this stimulus for anyone older than 2 years is to curl the toes downward.

Question 3: PET scans can be used to measure blood flow in the cerebral cortex. What parts of the cortex show increased blood flow when a subject is asked to think about moving her right finger?

Answer: When subjects are asked to mentally rehearse finger movements without actually moving the fingers, area 6 is active but area 4 is not. The portion of area 6 called SMA sends

axons that innervate distal motor units. Therefore, this area is likely to be active when rehearsing finger movements rather than PMA, which innervates proximal motor units. When subjects actually move their fingers after rehearsing the movement mentally, area 4 of the cortex registers increased blood flow. This is because area 4 is involved in executing movements.

Question 4: Why is dopa used to treat Parkinson's disease? How does it act to alleviate the symptoms?

Answer: The organic basis of Parkinson's disease is a gradual degeneration of dopaminergic (DA) neurons in the substantia nigra that project to the striatum. DA normally facilitates the direct motor loop by activating cells in the putamen, which releases VLo from globus pallidus–induced inhibition. The depletion of dopamine in Parkinson's disease closes the funnel that feeds activity to SMA through the basal ganglia and VLo. Dopa is used to treat the depletion of dopaminergic input to the basal ganglia caused by Parkinson's disease. Dopa crosses the blood-brain barrier and boosts DA synthesis in the dopaminergic neurons that remain in the substantia nigra. While this treatment alleviates some of the symptoms, eventually many neurons are lost and dopa treatment is no longer effective. Dopa also has some troublesome side effects.

Question 5: Individual Betz cells fire during a fairly broad range of movement directions. How might they work together to command a precise movement?

Answer: Upper motor neurons are located in cortical layer V of M1. Layer V has a population of large pyramidal neurons called *Betz cells.* Betz cells were first described as a separate class

of cells by Russian anatomist Vladimir Betz in 1874. Single unit recordings in M1 by Georgopoulos and colleagues showed the following:

i) Most of the motor cortex is active during every movement.

ii) The activity of each cell represents a single "vote" for a particular direction of movement.

iii) The direction of movement is determined by a tally of the votes registered by each cell in the population.

iv) Although the population-coding scheme is hypothetical, experiments on the superior colliculus conclude that a population code is used by this structure to command precisely directed eye movements.

Question 6: Sketch the motor loop through the cerebellum. What movement disorders result from damage to the cerebellum?

Answer: Axons arising from layer V pyramidal cells in the sensorimotor cortex—frontal areas 4 and 6, somatosensory areas on the postcentral gyrus, and the posterior parietal areas—form a massive projection to clusters of cells in the pons, the pontine nuclei, which in turn feed the cerebellum. The lateral cerebellum projects back to the motor cortex through a relay in the ventral lateral nucleus of the thalamus. This completes the motor loop through the cerebellum. Damage to the cerebellum results in ataxia, dysynergia, and dysmetria. Ataxia is a condition in which movements become uncoordinated and inaccurate. Dysynergia is characterized by the decomposition of synergistic multijoint movements. Dysmetria is characterized by clumsiness similar to that which accompanies ethanol intoxication.