Question 1: According to the James-Lange and Cannon-Bard theories of emotion, what is the relationship between the anxiety you would feel after oversleeping for an exam and your physical responses to the situation?

Answer: According to the James-Lange theory of emotion, we experience emotion in response to physiological changes in our body, such as increased heart rate, inhibited digestion, and increased sweating. As a result of the body's response to the situation, the person becomes afraid. According to the Cannon-Bard theory, emotional experience is independent of emotional expression. The threatening stimulus first causes a feeling of fear and the physiological reaction follows.

Question 2: How has the definition of the limbic system and thoughts about its function changed since the time of Broca?

Answer: French neurologist Paul Broca named the collection of cortical areas that form a ring around the brain stem limbic lobe (cingulated gyrus, medial temporal lobe, including the hippocampus). There was no mention of emotion; the structures were primarily thought to be involved in olfaction. By the 1930s, evidence suggested that a number of limbic structures were involved in emotion. American neurologist James Papez proposed an "emotion system" on the medial wall of the brain, which linked the cortex with the hypothalamus (cingulated cortex, hippocampus, hypothalamus, anterior nuclei of the thalamus). Papez believed that damage to certain cortical areas caused profound changes in emotional expression with little change in perception or intelligence. Papez proposed that activity in the cingulated cortex adds emotional coloring. The term limbic system was popularized in 1952 by American physiologist Paul MacLean. According to MacLean, the evolution of a limbic system enabled

animals to experience and express emotions. It freed animals from the stereotypical behavior dictated by their brain stem. Some of the components of the Papez circuit are no longer thought to be important for the expression of emotion, such as the hippocampus. In addition, some structures involved in emotion are also involved in other functions, and some researchers question the utility of trying to define a single, discrete emotion system.

Question 3: What procedures will produce an abnormal rage reaction in an experimental animal? How do we know that the animals *feel* angry?

Answer: The removal of the cerebral hemispheres produces abnormal rage reactions in experimental animals. Experiments performed in the 1920s showed a remarkable behavioral transformation in cats or dogs when this procedure was performed. Animals that were not easy to provoke prior to the surgery flew into a state of violent rage with the least provocation after the surgery. Sham rage is observed if the anterior hypothalamus is destroyed along with the cortex, but it is not seen if the lesion is extended to include the posterior half of the hypothalamus. Therefore, the posterior hypothalamus is particularly important for the expression of anger and aggression in animals and is normally inhibited by the telencephalon. We do not know whether or not the animals feel angry, because feelings are subjective experiences that can be reported verbally by humans but not by rats.

Question 4: What changes in emotion were observed following temporal lobectomy by Klüver and Bucy? Of the numerous anatomical structures they removed, which is thought to be closely related to changes in temperament?

Answer: Neuroscientists Heinrich Klüver and Paul Bucy found that the bilateral removal of temporal lobes, also called temporal *lobectomy*, in rhesus monkeys had a dramatic effect on

the animals' fear and aggression, which were decreased. The animals were placid in the presence of humans and other animals that they normally fear, such as snakes. The animals showed a decrease in vocalizations and facial expressions typically associated with fear. It appeared that both the normal experience and normal expression of fear and aggression were severely decreased. Amygdala appears to be a critical element in the brain circuitry that processes fear and aggression. It is thought to be closely associated with changes in temperament. The removal of amygdala reduces fear and aggression in experimental animals.

Question 5: Why might performing bilateral amygdalectomy on a dominant monkey in a colony result in that monkey's becoming a subordinate?

Answer: Evidence indicates that amygdala is involved in aggressive behavior. Lesions of the amygdala may result in the flattening of emotion and other behavioral abnormalities. Bilateral amygdalectomy in animals can profoundly reduce fear and aggression. Therefore, bilateral amygdalectomy on a dominant monkey will make the monkey placid and less difficult to challenge. As a result, the second monkey in the hierarchy will push the dominant monkey to a subordinate position. Electrical stimulation of the amygdala may produce a state of agitation or affection aggression.

Question 6: What assumptions about limbic structures underlie the surgical treatment of emotional disorders?

Answer: The assumption that the limbic system controls emotion led to the conclusion that people with emotional problems can be helped by altering the system surgically. In the 1930s, John Fulton and Carlyle Jacobsen of the Yale University reported that frontal lobe lesions had a calming effect in chimpanzees. It has been suggested that frontal lesions have

this effect because of the destruction of limbic structures, particularly in connection with frontal and cingulate cortex. (This surgery is also associated with blunted emotions, inappropriate behavior, difficulty in planning and working toward goals, and difficulty in concentrating.) In addition, reduced aggression in amygdalectomized animals led some neurosurgeons to use this method in humans. Clinical reports claim considerable success in reducing aggressive asocial behavior, increasing the ability to concentrate, decreasing hyperactivity, and reducing seizures with this type of brain surgery.

Question 7: The drug known as Prozac is a serotonin-selective reuptake inhibitor. How does this drug affect a person's level of anxiety and aggression?

Answer: The neurotransmitter serotonin is involved in regulating aggression; decreased serotonin is associated with an increase in aggression, and increased serotonin is associated with decreased aggression. The link between aggression and anxiety is not perfectly clear, but it is known that serotonin antagonists increase aggressiveness and agonists of the 5-HT1B and 5-HT1B serotonin receptors decrease anxiety and aggressiveness in mice. It is also known from experimental work in animals that anxiety and aggression increase and decrease together. Prozac is a selective serotonin reuptake inhibitor (SSRI) that effectively increases the amount of serotonin in the synaptic cleft by preventing its reuptake into the presynaptic element. This increase in serotonin availability is associated with decreased anxiety, so in addition to its use as an antidepressant, Prozac and other SSRIs are used as antianxiety agents.