Question 1: Suppose you have just been captured by aliens who have landed on Earth to learn about humans. The aliens are all one gender, and they are curious about the two human genders. To earn your freedom, all you must do is tell them how to reliably distinguish males from females. What biological or behavioral tests do you tell them to conduct? Be sure to describe any exceptions that might violate your gender tests—you don't want the aliens to get angry!

Answer: There are many biological characteristics and qualities that distinguish between males and females, including the sex chromosomes, the anatomy of the reproductive organs, and secondary sex characteristics, such as hair distribution and mammary glands. The most reliable test of gender is to examine the chromosomes. Females have two X chromosomes whereas males have an X chromosome from the mother and a Y chromosome from the father. In rare cases, there are too few or too many sex chromosomes but gender is always determined by the presence or absence of the Y chromosome. Another important exception is androgen insensitivity syndrome. A genetic male has the phenotypic appearance of a female because his androgen receptors are insensitive to this masculinizing hormone and his body follows the default pathway, which is to develop female secondary sexual characteristics and gender identity.

Question 2: Trace the chain of events that might link psychological stress and reduced male sperm production and potency.

Answer: Neural activity in the hypothalamus is influenced by numerous psychological and environmental factors, which can cause changes in the release of gonadotropin-releasing hormone (GnRH). GnRH controls the release of LH and FSH from the pituitary gland. LH

and FSH are particularly important for normal sexual development and function in both males and females. LH and FSH play vital roles in male fertility. LH stimulates the testes to produce testosterone, and FSH is involved in the maturation of sperm cells within the testes. Stress may alter male potency by influencing the neural activity of the hypothalamus and the release of GnRH.

Question 3: Figure 17.14 shows an interesting but unexplained observation: In the brain of a mother rat during periods of lactation, the size of the somatosensory cortex representing the skin around the nipples expands. Speculate about a likely mechanism for this phenomenon. Suggest a reason why such brain plasticity might be advantageous.

Answer: Sexually dimorphic changes in the brain are sometimes transient or cyclical, coinciding with the sexual behavior to which they are related. In female rats, the somatosensory cortex contains a sensory representation of the ventral skin surrounding the nipples. This representation expands dramatically but temporarily across the cortex when the mother rat nurses her young. This is an example of somatosensory map plasticity. The cortical region in a lactating rat is enlarged compared with that of a nonlactating rat. Regions of somatosensory cortex subserving other regions of the body are not affected by the lactating state. Experiments reveal that topographic maps in somatosensory cortex are dynamic, and adjust depending on the amount of sensory experience. The relative size of cortex devoted to each body part is correlated with the *density* of sensory input received from that part. Size on the map is also related to the *importance* of the sensory input from that part of the body. Perhaps the observed plasticity in the lactating rat's somatosensory cortex is mediated by changes in the receptor density in the nipple area related to lactation, and the sensory input related to

suckling pups. Hormones related to lactation, such as oxytocin, may enhance cortical plasticity in lactating rats.

Question 4: Estradiol is typically described as a female sex hormone, but it also plays a critical role in the early development of the male brain. Explain how this happens, and why the female brain is not similarly affected by estradiol.

Answer: The testes produce androgens, which trigger the masculinization of the nervous system by regulating the expression of a variety of sex-related genes. In the absence of androgens, the brain is feminized through a different pattern of gene expression. But it is not testosterone that causes the changes in gene expression; it is estrogen that triggers masculinization of the developing nervous system. Testosterone is converted within the neuronal cytoplasm into estradiol in a single chemical step catalyzed by the enzyme aromatase. Because female gonads do not produce an estrogen surge in early stages of development, female brains normally escape this steroid-triggered transformation.

Question 5: Where and how can steroid hormones influence neurons in the brain, at the cellular level?

Answer: There are several examples of the cellular effects of steroid hormones. 1) Neurite outgrowth increases in the hypothalamic neurons of newborn mice treated with estradiol, and estradiol increases cell viability and spine density. 2) A particularly fascinating example is the estradiol-related increase in dendritic spines on hippocampal neurons in female rats. Dendritic spine numbers fluctuate dramatically during the 5-day estrous cycle, increasing with estradiol levels. This effect is mediated by inhibitory interneurons with estradiol receptors. Increases in estrogen decrease GABA production so the hippocampus has less

inhibition. Decreased inhibition leads to an overall increase in neural activity and an increase in spines and excitatory synapses on the pyramidal cells. 3) Estradiol also has a protective effect on neurons. Cells in culture that are exposed to extradiol are more likely to survive hypoxia, oxidative stress, and exposure to various neurotoxic agents. These protective effects are not well understood but probably involve multiple cellular mechanisms.

Question 6: Suppose a research team has just claimed that a small and obscure nucleus in the brain stem, nucleus X, is sexually dimorphic and essential for certain "uniquely male" sexual behaviors. Discuss the kinds of evidence you would need to accept these claims about (a) the existence of a dimorphism, (b) the definitions of uniquely male behaviors, and (c) the involvement of nucleus X in these sexual behaviors.

Answer: a) Evidence of sexual dimorphism in neural structures requires quantitative analysis of tissue from the brains of male and female animals that are the same age and from the same type of environment. The tissue also needs to be handled in exactly the same ways for histological preparation. Because the quantitative differences are likely to be small, large numbers of brains should be examined. It would be best to show sexual dimorphism in more than one species if possible and to look at the development of the dimorphism pre- and postnatally. b) Uniquely male behaviors associated with copulation are easy to observe and quantify. Other "uniquely" male behaviors related to aggression are also observable but need good operational definitions. c) Demonstrating the link between the dimorphic structure and uniquely male behavior may include lesion studies where obliterating the structure obliterates the sexual behavior. Demonstrating the male behavior in androgenized females who also show masculinization of the sexually dimorphic brain structure is also a powerful

demonstration of the link between the structure and the behavior. You may also try blocking the androgen receptors as a way to reverse the sexual dimorphism in male animals.