Answer Key
The Human Nervous System

1. **D—**The substantia nigra is located in the midbrain. The substantia nigra, along with four other nuclei, is part of the basal ganglia. It is the largest nucleus in the midbrain.

2. **B—**Terminal buttons are structures on the end of the axon that are rich in synaptic vesicles.

3. **A—**Damage caused to Wernicke's area, located in the temporal lobe in the dominant cerebral hemisphere, results in receptive, fluent aphasia. This means that the person with aphasia will be able to fluently connect words, but the phrases will lack meaning.

4. **A—**Broca's aphasia is another term for expressive aphasia.

5. **A—**The motor cortex is the region of the cerebral cortex involved in the planning, control, and execution of voluntary movements. It is in an area of the frontal lobe located in the dorsal precentral gyrus immediately anterior to the central sulcus. The motor cortex located on the right side of the brain controls movement on the left side of the body.

6. **D—**The reticular formation is a set of interconnected nuclei that are located throughout the brainstem which play a crucial role in maintaining behavioral arousal and consciousness. It is not part of the limbic system.

7. **C—**GABA is the chief inhibitory neurotransmitter in the central nervous system.

8. **A—**The amygdalae perform a primary role in the processing of memory, decision-making, and emotional reactions. Bilateral lesion of amygdala in monkey demonstrated that there is massive reduction of fear and aggression.The monkeys also become more friendly sexually and non-sexually towards other monkeys.

9. **A—**Because left brain structures typically control speech, split brain patients have difficulty speaking about visual information processed in their right hemisphere. The portion of the visible field affected are the inputs reaching the left portion of each eye.

10. **D—**The hippocampi are elongated ridges on the floor of each lateral ventricle of the brain. They are a center for memory, spatial cognition, and conflict processing functions in the brain.

11. **C—**The sodium channels close at the peak of the action potential. Potassium ions continue to leave the cell. The efflux of potassium ions subsequently decreases the membrane potential or hyperpolarizes the cell.

12. **A—**The motor cortex is the region of the cerebral cortex involved in the planning, control, and execution of voluntary movements. It's location is an area of the frontal lobe located in the dorsal precentral gyrus immediately anterior to the central sulcus.

13. **C—**The primary motor cortex in the frontal lobe is separated from the primary somatosensory cortex in the parietal lobe by the central sulcus.

14. **B—**Damage to the right parietal lobe can result in contralateral leglect, a lack of attention to the left half of the body.

15. **C—**The temporal lobe plays a central role in hearing, understanding language, and autobiographical memory. The auditory cortex is located in the top of the temporal lobe. The language area of the temporal lobe is called Wernicke's area, though a portion of the parietal lobe is also included in Wernicke's area. The lower part of the temporal lobe is critical to encoding autobiographical memory.

16. A—Parkinson's disease is characterized, in part, by the death of dopaminergic neurons in the substantia nigra. The major projection from the substantia nigra is to nuclei of the basal ganglia. The basal ganglia receive inputs from multiple cortical areas, and then project to the motor cortex via the thalamus. The basal ganglia integrate these multiple inputs to modulate the output of the motor cortex. The loss of dopaminergic input from the substantia nigra alters the balance of the output from the basal ganglia to the motor cortex, which underlies the symptoms of Parkinson's.

17. C—Every sensory system (with the exception of the olfactory system) includes a thalamic nucleus that receives sensory signals and sends them to the associated primary cortical area.

18. B—Current theories implicate the basal ganglia primarily in action selection; that is, in helping determine the decision of which of several possible behaviors to execute at any given time. In more specific terms, the basal ganglia's primary function is likely to control and regulate activities of the motor and premotor cortical areas so that voluntary movements can be performed smoothly.

19. A—Glutamate is the main excitatory neurotransmitter in the central nervous system. Chemical receptors for glutamate fall into three major classes: AMPA receptors, NMDA receptors, and metabotropic glutamate receptors. AMPA receptors are ionotropic receptors specialized for fast excitation: in many synapses they produce excitatory electrical responses in their targets a fraction of a millisecond after being stimulated. NMDA receptors are also ionotropic, but they differ from AMPA receptors in being permeable, when activated, to calcium. Their properties make them particularly important for learning and memory. Metabotropic receptors act through second messenger systems to create slow, sustained effects on their targets.

20. A—Monoamine neurotransmitters are neurotransmitters and neuromodulators that contain one amino group that is connected to an aromatic ring by a two-carbon chain (-CH2-CH2-). All monoamines are derived from aromatic amino acids like phenylalanine, tyrosine, tryptophan, or the thyroid hormones. Acetylcholine, however, is an ester of acetic acid and choline.

21. D—Of the four major dopaminergic pathways, the mesolimbic pathway transmits dopamine from the ventral tegmental area (VTA) to the nucleus accumbens (reward and aversion related cognition). The mesocortical pathway transmits dopamine from the VTA to the prefrontal cortex (executive functions). The nigrostriatal pathway transmits dopamine from the substantia nigra pars compacta (SNc) to the caudate nucleus and putamen (motor function, reward cognition, associative learning). The tuberoinfundibular pathway transmits dopamine from the hypothalamus (arcuate nucleus aka "infundibular nucleus") to the pituitary gland (influencing the secretion of certain hormones including prolactin). Although the adrenal medulla also produces dopamine, a precursor to epinephrine and norepinephrine, the adrenal glands are not part of the CNS.

22. C—The equilibrium potential for an ion is the membrane potential where there would be no net movement across the membrane even with open diffusion channels. In this state, the Nernst potential due to the concentration gradient is equal but opposite to the electrical voltage. Because membranes have chloride channels but not active transport pumps, equilibrium diffusion potential of chloride ion across a typical nerve cell membrane exactly opposes the resting potential of the neuron (approximately -70 mV).

23. B—The threshold potential is the critical level to which a membrane potential must be depolarized to initiate an action potential. Most often, the threshold potential is a membrane potential value between –50 and –55 mV,

24. **C—**If a graded potential increases past a critical threshold, typically 15 mV higher than the resting value, a runaway condition occurs and the cell fires, producing an action potential. As the membrane potential is increased, sodium ion channels open, allowing the entry of sodium ions into the cell. This is followed by the opening of potassium ion channels that permit the exit of potassium ions from the cell. The sodium channels close at the peak of the action potential, while potassium continues to leave the cell. The efflux of potassium ions decreases the membrane potential hyperpolarizing the cell.

25. **A—**An EPSP (excitatory postsynaptic potential) is depolarizing not hyperpolarizing. An EPSP brings the membrane potential closer towards threshold potential. An increase in the membrane permeability of sodium is typically the cause of an EPSP. On the contrary, an increase in the permeability of the postsynaptic membrane for potassium or chloride produces an IPSP (inhibitory postsynaptic potential).

26. **B—**In the Alzheimer's disease process, cholinergic neurons projecting from lower brain areas up to higher brain areas are selectively lost.

27. **B—**Efferent nerve pathways in both the sympathetic and parasympathetic nervous system consist of two neuron chains. The ganglion is the site of synapses between the two segments, the pre- and post-ganglionic fibers. In both the sympathetic and parasympathetic nervous systems, acetylcholine is the neurotransmitter in the ganglia. Acetylcholine is also the neurotransmitter at the effector organ in the parasympathetic nervous system, but norepinephrine is the neurotransmitter at the effector organ within the sympathetic nervous system.

28. **C—**In axonal transport kinesin and dynein are motor proteins that move cargoes. Kinesin moves in the anterograde direction (forwards from the soma to the axon tip). Dynein moves in the retrograde (towards the soma) direction.

29. **A—**Nicotinic and muscarinic receptors are two main classes of acetylcholine receptor, named for chemicals that can selectively activate each type of receptor without activating the other.

30. **D—**Performing a similar function to Schwann cells in the PNS, oligodendroglia are cells that coat axons in the central nervous system (CNS) with myelin, producing the myelin sheath. Astrocytes form the blood-brain barrier. They regulate the external chemical environment of neurons by removing excess potassium ions, and recycling neurotransmitters released during synaptic transmission. Ependymal cells line the spinal cord and the ventricular system of the brain. These cells are involved in the creation and secretion of cerebrospinal fluid (CSF). Microglia are specialized macrophages that protect neurons of the central nervous system.

31. **D—**A scotoma is an area of partial alteration in the field of vision consisting of a partially diminished or entirely degenerated visual acuity that is surrounded by a field of normal – or relatively well-preserved – vision. A scotoma may be the result of a lesion within the primary visual cortex, which is located in the occipital lobe.

32. **A—**The part of the visual cortex that receives the sensory inputs from the thalamus is the primary visual cortex, also known as visual area one (V1), and the striate cortex. The extrastriate areas consist of visual areas two (V2), three (V3), four (V4), and five (V5). Cells of the V2 cortex have been demonstrated to play a very important role in the storage of object recognition memory as well as the conversion of short-term object memories into long-term memories.

33. **B—**Located throughout the brain and spinal cord, microglia account for 10–15% of all cells found within the brain. As the resident macrophage cells, they act as the first and main form of active immune defense in the central nervous system (CNS).

34. **B—**One type of convergence occurs when multiple synaptic terminals from a single pre-synaptic neuron communicate with a single post-synaptic neuron. Another type of convergence occurs from multiple sources allowing different tracts to excite a single neuron thus allowing spatial summation (as opposed to temporal summation) of information from different sensory organs. The summation of multiple EPSPs leads to excitation of the post-synaptic neuron.

35. **A—**In presynaptic inhibition, a minimum of three neurons must be involved. The first synapses upon a second. A third neuron regulates the synapse between the first two by its own synapse upon the excitatory terminal of the first, an axo-axonic synapse interacting with the primary connection. The effect may be to open chloride channels or modulate calcium channels.

36. **D—**An agonist functions in the same manner as the naturally occurring neurotransmitter. Morphine, with a similar chemical structure, is an agonist of the brain neurotransmitter endorphin.

37. **C—**All choices are primitive reflexes. Primitive reflexes are reflex actions originating in the central nervous system that are exhibited by normal infants, but not neurologically intact adults, in response to particular stimuli. Babinski sign is also known as the plantar reflex.

38. **B—**Much of the language function is processed in several association areas, and there are two well-identified areas that are considered vital for human communication: Wernicke's area and Broca's area. These areas are usually located in the dominant hemisphere (the left hemisphere in 97% of people) and are considered the most important areas for language processing.

39. **D—**This is the equal environments assumption.

40. **A—**The dorsal telencephalon, or pallium, develops into the cerebral cortex.

41. **D—**All are forebrain (prosencephalon) structures except the medulla, which is a hindbrain (rhombencephalon) structure.

42. **D—**In addition to these changes, underdevelopment of the left brain, a smaller corpus collosum, and neuro-endocrine alterations have also been associated with a history of child abuse or trauma.

43. **C—**Neuromodulation is the physiological process by which a given neuron uses one or more chemicals to regulate diverse populations of neurons. This is in contrast to classical synaptic transmission, in which one presynaptic neuron directly influences a single postsynaptic partner. Neuromodulators secreted by a small group of neurons diffuse through large areas of the nervous system, affecting multiple neurons. Major neuromodulators in the central nervous system include dopamine, serotonin, acetylcholine, histamine, and norepinephrine.

44. **A—**The notochord is derived from mesoderm. Formed during gastrulation, the notochord induces the formation of the neural plate (neurulation) within nearby ectoderm. A postembryonic vestige of the notochord is found in the nucleus pulposus of the intervertebral discs.

45. **C—**The basal ganglia consist of multiple subcortical nuclei, of varied origin situated at the base of the forebrain. Currently, popular theories implicate the basal ganglia primarily in action selection; that is, it helps determine the decision of which of several possible behaviors to execute at any given time. In more specific terms, the basal ganglia's primary function is likely to control and regulate activities of the motor and premotor cortical areas so that voluntary movements can be performed smoothly. Experimental studies show that the basal ganglia exert an inhibitory influence on a number of motor systems, and that a release of this inhibition permits a motor system to become active. The "behavior switching" that takes place within the basal ganglia is influenced by signals from many parts of the brain, including the prefrontal cortex, which plays a key role in executive functions.

46. **C—**There is high sibling correlation but little heritability. In judging the influence of genes of environment on trait X, environmental variance is much higher than heritability.

47. **B—**Synaptic pruning or axon pruning is the process of synapse elimination that occurs between early childhood and the onset of puberty. The purpose of this type of synaptic pruning (regulatory pruning) is to remove unnecessary neuronal structures from the brain; as the human brain develops, the need to understand more complex structures becomes much more pertinent, and simpler associations formed at childhood are replaced by complex structures. The pruning that is associated with learning is known as small-scale axon terminal arbor pruning. Axons extend short axon terminal arbors toward neurons within a target area. Certain terminal arbors are pruned by competition. The selection of the pruned terminal arbors follow the "use it or lose it" principle seen in synaptic plasticity. This means synapses that are frequently used have strong connections while the rarely used synapses are eliminated.

48. **D—**The primary role of SNARE proteins is to mediate vesicle fusion, that is, the fusion of vesicles with their target membrane bound compartments. The best studied SNAREs are those that mediate docking of synaptic vesicles with the presynaptic membrane in neurons.

49. **A—**Synaptotagmin is a Ca^{2+} sensor in the membrane of the pre-synaptic axon terminal.

50. **A—**The reticular activating system is a set of connected nuclei in the brains of vertebrates that is responsible for regulating wakefulness and sleep-wake transitions. Its most influential component is the reticular formation. The two most common causes of prolonged coma are diffuse axonal injury following traumatic brain injury or a brainstem lesion involving the reticular activating system.