Answers to Questions for Comprehension

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Q1. Homeostasis is the maintenance of a constant internal environment. Slight fluctuations above and below these "normal" levels are common, so our internal systems are often said to be in a state of dynamic equilibrium.

Q2. The human nervous system can regulate tens of thousands of activities simultaneously. Its overall function is to collect information about the external conditions in relation to the body's internal state, to analyze this information, and to initiate appropriate responses to maintain homeostasis.

Q3.

System	Structure	Function
Central Nervous System	■ brain ■ spinal cord	■ The spinal cord carries messages from the body to the brain. ■ The brain analyzes and interprets these messages. ■ The brain then passes response messages through the spinal cord to the target structure—a muscle, a gland, or another neuron.
Peripheral Nervous System	■ somatic nervous system ■ autonomic nervous system	■ This system relays information to and from the skin and skeletal muscles under conscious control. ■ The sympathetic nervous system controls organs in times of stress (fight or flight). ■ The parasympathetic nervous system causes a return to a state of rest and controls organs when the body is at rest.

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Q4. Neurons are the basic structural and functional units of the nervous system. They are specialized to respond to physical and chemical stimuli, to conduct electrochemical signals, and to release chemicals that regulate various body processes.

Glial cells support neurons. These cells nourish the neurons, remove their wastes, and defend against infection. Glial cells also provide a supporting framework for all of the nervous-system tissue.

Q5. The three types of neuron are the sensory neuron, interneuron, and motor neuron.

- Sensory neurons gather information from sensory receptors and transmit these impulses to the central nervous system.
- Interneurons are found entirely within the central nervous system. They act as a link between the sensory and motor neurons. They process and integrate incoming sensory information, and relay outgoing motor information.
- Motor neurons transmit information from the central nervous system to muscles, glands, or other organs (effectors).

Q6. The basic neural pathway used is a reflex arc, which is a withdrawal reflex in this example.

Sense organ (eye) detects the ball → sensory neuron → spinal cord (interneuron) → motor neuron → causes muscle to act to withdraw (move the head) out of the way of the ball

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Q7. Students' drawings should be similar to the motor neurons shown in Figure 11.9 on page 372 of the student textbook. The diagram should include the following labels: dendrites, cell body, axon, Schwann cell, and the node of Ranvier.

Q8. The axons of some neurons are enclosed in a fatty, insulating layer called the myelin sheath, which gives the axons a glistening white appearance. These axons are said to be myelinated. The myelin sheath protects myelinated neurons and speeds the rate of nerve impulse transmission. Schwann cells, a type of glial cell, produce myelin in certain parts of the CNS and PNS.

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Q9. The charge difference across the membrane in a resting neuron is called the resting membrane potential. The resting membrane potential of most unstimulated neurons is –70 mV (millivolts), and it is more negative on the inside. The resting membrane potential provides energy for the generation of a nerve impulse in response to an appropriate stimulus.

Q10. Neurons achieve polarization (i.e., generate resting membrane potential) in 3 ways:

1. Some negatively charged substances, such as proteins and chloride ions (Cl^-), are trapped inside the cell and unable to diffuse out through the selectively permeable cell membrane.
2. Sodium ions (Na^+) and potassium ions (K^+) cannot diffuse unaided from one side of the cell membrane to the other. Special membrane proteins, however, can use the energy of ATP to pump charged particles across the membrane. This **s**odium-potassium pump pumps out *3* sodium ions for every *2* potassium ions pumped into the cell, which results in an unequal distribution of positive charges on either side of the membrane. The buildup of positive charges on the outside of the cell creates an electric potential.
3. Special transport proteins form ion-specific channels that allow potassium ions to diffuse down their concentration gradient and out of the cell. There are sodium ion channels as well, but, in a resting neuron, there are more open channels for potassium ions than for sodium ions. As a result, more potassium ions diffuse out of the cell relative to the number of sodium ions diffusing in, which contributes to the buildup of positive charges on the outside of the membrane.

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Q11. Depolarization of the neuron takes place if the stimulus is weak. In this case only a small number of channels will open and some sodium will start to diffuse down its concentration gradient and into the neuron. This process changes the membrane potential, causing depolarization of the membrane. If the charge inside the cell stays close to –70 mV; however, no impulse will be generated.

An action potential is a wave of depolarization that sweeps along the neuron. If a threshold potential is reached, large numbers of sodium ion channels simultaneously open, allowing for an influx of sodium ions and rapid depolarization of the membrane. This rapid change in the membrane potential from –70 mV to about +35 mV initiates a nerve impulse, called an action potential.

Q12. An action potential has an all-or-none response. Each depolarization event either reaches the threshold potential, causing an action potential, or does not. Furthermore, an action potential has only one strength or magnitude. In other words, the axon cannot fire a stronger or weaker action potential.

Q13. Immediately after the sodium ion channels open, the change in membrane potential to +35 mV triggers certain potassium ion channels to open. The potassium ions rush out of the membrane, down their concentration gradient to the outside of the neuron. This event, which helps to restore the resting membrane potential, is called repolarization.

When the neuron begins to repolarize, the sodium-potassium pump is reactivated. Once again, sodium ions are pumped out of the neuron. In addition, ion-specific channels open, allowing chloride to diffuse into the cell. The combination of sodium and potassium ions on the outside of the neural membrane and chloride ions on the inside causes a rapid drop in membrane potential from +35 mV to –90 mV. The drop in membrane potential below resting membrane potential is called hyperpolarization.

The voltage-activated potassium ion channels then close, and the membrane returns to its resting state of –70 mV. The return to resting membrane potential following the initial depolarization is called the refractory period. Until the neuron goes through the refractory period, it cannot be stimulated again.

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Q14. A neural impulse is the movement of action potentials and the consequent repolarization along the neuron. The impulse begins as a movement of ions across a localized area of the cell membrane, which reverses the polarity of the membrane potential in the area. This reversal of polarity results in depolarization in the neighbouring area of the membrane, which has the same effect on the next area of the membrane, and so on. In this way, the impulse propagates in one direction along the length of the neuron, with sodium ion channels and then potassium ion channels opening up in one area after another.

Q15. An action potential travels the length of the axon until it reaches the far end, called the synaptic terminal. Synaptic vesicles move toward and fuse with the presynaptic membrane. Neurotransmitters are released into the synaptic cleft and diffuse across the cleft to the postsynaptic membrane where they bind to receptor proteins and affect the postsynaptic neuron.

Q16. Neurotransmitters carry the neural signal from one neuron to another. Neurotransmitters can also carry the neural signal from a neuron to an effector, such as a gland or a muscle fibre.

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Q17. Neurotransmitters have either excitatory or inhibitory effects on the postsynaptic membrane. If the effect is excitatory, the receptor proteins will trigger the opening of ion channels that allow positive ions, such as sodium, to flow into the postsynaptic neuron. This depolarizes the postsynaptic membrane and, if the threshold potential is reached, initiates an action potential. The impulse that is initiated will travel along the axon to the next neuron or effector.

If, however, the neurotransmitter has an inhibitory effect, the receptor protein will trigger hyperpolarization of the membrane. This means that the inside of the axon will become even more negatively charged. As a result, the membrane will not depolarize and there will be no action potential.

Q18. Acetylcholine is a neurotransmitter that crosses a neuromuscular junction. Acetylcholine excites the muscle cell membrane, causing depolarization and contraction of the muscle fibre.

Cholinesterase is an enzyme that is released into a synapse to break down acetylcholine. Cholinesterase is one of the fastest acting enzymes; in a fraction of a second it breaks down acetylcholine and removes it from the protein receptors, thus allowing the ion channels to close and the membrane to repolarize.

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Q19. The spinal cord and the brain make up the central nervous system, where sensory information is received and motor control is initiated. The central nervous system (brain and spinal cord) receives information from the senses, evaluates this information, and initiates outgoing responses to the body. The spinal cord is a column of nerve tissue that extends out of the skull from the brain and downward through a canal within the backbone. The spinal cord serves as a means of communication between the brain and the peripheral nervous system. The spinal cord is also a centre for reflex actions. The brain maintains homeostasis within the body: the brain processes information transmitted through the senses so the body can deal with changes in the external and internal environment. The brain is also responsible for reasoning, learning, memory, language, and speech.

Q20. The meninges protect the CNS by preventing the direct circulation of blood through the cells of the brain and spinal cord. The blood-brain barrier both protects the brain and supplies the brain with nutrients and oxygen. The blood capillaries that lead to the brain are made up of tightly fused epithelial cells. Thus, the capillary walls form a barrier that blocks many toxins and infectious agents. Some substances, such as glucose and oxygen, can still pass through the barrier using special transport mechanisms. Other lipid-soluble substances are able to pass directly through the lipid bilayer of the cell membrane. Circulating throughout the spaces, or ventricles, within the brain and spinal cord is the cerebrospinal fluid. It circulates between two layers of the meninges, the arachnoid and pia mater, and acts as a shock absorber to cushion the brain.

Q21. The hypothalamus helps to maintain homeostasis by:

- controlling blood pressure
- controlling heart rate
- controlling body temperature
- coordinating the actions of the pituitary gland, by producing and regulating the release of many hormones that maintain homeostasis.

The medulla oblongata regulates involuntary actions such as heart rate, constriction or dilation of blood vessels to control blood pressure, and rate and depth of breathing.

Q22. The following chart can be used to summarize the information required to answer this question.

Region	Structure	Function
hindbrain	cerebellum	■ unconscious control of posture, reflexes, and body movements ■ control of fine, voluntary motor skills ■ receives information from specialized sensors

Region	Structure	Function
	medulla oblongata	■ controls automatic, involuntary responses such as heart rate, blood pressure, breathing, swallowing, and coughing
	pons	■ a relay centre between the neurons of the right and left hemispheres of the cerebrum, the cerebellum, and the rest of the brain
midbrain	midbrain	■ relays visual and auditory information between areas of the hindbrain and forebrain ■ plays important role in eye movement and control of skeletal muscles
forebrain	thalamus	■ provides connections between the forebrain and hindbrain, and between areas of the sensory system and cerebellum
	hypothalamus	■ controls blood pressure, heart rate, body temperature, basic drives, emotions ■ major link between the nervous and endocrine systems
	cerebrum	■ contains centres for intellect, memory, consciousness, and language ■ interprets and controls the response to sensory information

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Q23. The following chart identifies the 4 lobes of the cerebrum and describes the function of each.

Lobes of the Cerebrum	Functions
frontal lobe	associated with conscious thought, intelligence, memory, and personality; controls voluntary muscle movements
temporal lobe	involved in auditory reception
parietal lobe	receives sensory information from the skin, and processes information about body position
occipital lobe	processes visual information

Q24. The areas of the brain responsible for fine motor control of the muscles are the frontal lobe of the cerebrum and the cerebellum. The area that processes sensory information from the skin is the parietal lobe of the cerebrum.

Q25. The process of speech involves several areas of the cerebrum. Two important areas are on the left side of the cerebrum: Broca's area (in the frontal lobe) and Wernicke's area (in the temporal lobe). Broca's area coordinates the muscles for speaking and translates thought into speech. Damage to this area results in an inability to speak. It does not, however, affect the understanding of language. Wernicke's area stores the information involved in language comprehension. The ability to utter words is not affected if this area is damaged, but the words make little sense.

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Q26. Scientists first learned about brain functions by studying the brains of people with brain injuries or diseases. For example, injured soldiers would sometimes have damage to certain areas of the brain, but still survive. Researchers could then link the injured area of the brain to loss of functions in other areas of the body. Brain mapping, or operating on the brain of a conscious person, was one way to determine the function of different regions of the cerebral cortex.

Q27. PET can show different levels of activity in the brain, and can be used to diagnose conditions such as a stroke or Alzheimer's disease, in which the deterioration of the brain leads to memory loss, confusion, and eventual lack of conscious movement. Because active areas of the brain have higher energy demands, radioactively labelled glucose fed to patients shows up on a screen as different colours representing different activity levels in the brain.

MRI can produce very clear and detailed images of brain structure, and can be used to identify various brain disorders, such as brain tumours. A giant magnet surrounds the patient's head, and changes in the direction of the magnetic field induce hydrogen atoms in the brain to emit radio signals. These signals can then be detected, translated, and displayed as a structural or functional image.

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Q28. The major structures of the somatic nervous system are 12 pairs of myelinated cranial nerves and 31 pairs of myelinated spinal nerves.

Q29. The somatic system is largely under voluntary control, and its neurons service the head, trunk, and limbs. Its sensory neurons carry information about the external environment inward to the brain, from the receptors in the skin, tendons, and skeletal muscles. Its motor neurons carry information to the skeletal muscles.

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Q30. The motor neurons involved in the autonomic nervous system are part of either the sympathetic nervous system or the parasympathetic nervous system, and either stimulate or inhibit the glands or the cardiac or smooth muscle.

Q31. Stress or danger is likely to trigger a response from the sympathetic nervous system, sometimes called a "fight-or-flight" response. The sympathetic neurons release a neurotransmitter called norepinephrine, which has an excitatory effect on its target muscles. As well, the sympathetic nerves trigger the adrenal glands to release epinephrine and norepinephrine, both of which also function as hormones that activate the stress response. At the same time, the sympathetic nervous system inhibits some areas of the body. For example, in order for someone to be able to run from danger, the skeletal muscles need a boost of energy. Therefore, blood pressure increases and the heart beats faster, while digestion slows down and the sphincter controlling the bladder relaxes.

Q32. The parasympathetic nervous system is activated when the body is calm and at rest. Sometimes referred to as the "rest-and-digest" response, the parasympathetic nervous system slows the heart rate, reduces blood pressure, promotes the digestion of food, and stimulates the reproductive organs by dilating blood vessels to the genitals. The parasympathetic system uses a neurotransmitter called acetylcholine to control organ responses.