Section 11.1: Review Answers

Student Textbook page 384

1. A – central nervous system
   B – peripheral nervous system
   C – sensory pathways
   D – motor pathways
   E – somatic nervous system
   F – autonomic nervous system
   G – sympathetic nervous system
   H – parasympathetic nervous system
2. Students' answers will depend on what they remember about electricity from Science 9.

Criteria	Electric Current in a Wire	Nerve Impulse
conductor	Electric currents travel along a conductor such as copper wire.	Electrochemical action causes the action potential to travel along the axon of a neuron.
propagation	Movement of an electric pulse along a wire involves the movement of electrons along the wire.	A nerve impulse is the result of ion concentration differences across the axon membrane.
strength of the impulse	The strength of an electrical current diminishes the farther you get from the source.	The strength of the action potential is the same along the entire length of the neuron.

Criteria	Electric Current in a Wire	Nerve Impulse
contact	Wires have to be in direct contact with each other in order for electricity to flow from one to the next.	Neurons are not in direct contact with each other. Neurotransmitters transmit the action potential from one neuron to another.
speed	Electricity in a wire travels much faster than the action potential in a neuron.	The action potential in a neuron travels much more slowly than electricity in a wire.
all-or-none	A switch regulates the flow of electrons through a circuit.	Once threshold potential is reached, an action potential will be generated in the neuron and will propagate the entire length of the neuron.

3. Myelinated neurons have a white, glistening appearance. The myelin sheath is an excellent insulator, protects myelinated neurons, and greatly enhances the speed of impulse conduction by forcing the impulse to jump from node to node along the axon, a process known as saltatory conduction. The fastest impulses, such as those in a reflex arc, travel at about 120 m/s. Schwann cells, a type of glial cell, produce myelin in certain parts of the nervous system. In the central nervous system, myelinated neurons form what is known as white matter. In the peripheral nervous system, most neurons are myelinated. Unmyelinated neurons form the grey matter in the central nervous system. The nerve impulses in unmyelinated neurons, such as those that stimulate smooth muscle in the digestive tract, travel at only about 2 m/s.

4. Students' answers should resemble Figure 11.12 on page 374 of the student textbook. The diagram should indicate that when a neuron is at rest, the outside of the membrane of the neuron is positively charged compared to the inside, which is at –70 mV. This is the result of the uneven distribution of positively and negatively charged ions. The diagram should show that outside the cell there is a high concentration of sodium (Na^+) ions and a lower concentration of potassium (K^+) ions. Inside the cell there is a high concentration of K^+ and a lower concentration of Na^+, as well as negatively charged ions such as chloride (Cl^-) and proteins. A neuron achieves this state in 3 ways: proteins and chloride ions (Cl^-), are trapped inside the cell and unable to diffuse out through the selectively permeable cell membrane; special membrane proteins can use the energy of ATP to pump charged particles across the membrane, but 3 sodium ions move out for every 2 potassium ions pumped into the cell; more ion-specific channels allow potassium ions to diffuse down their concentration gradient and out of the cell than channels allowing sodium ions to move into the cell. The value of this is that the resting membrane potential provides energy for the generation of a nerve impulse in response to an appropriate stimulus.

5. **(a)** The event occurring at Region 1 is that the membrane achieves resting potential. At Region 2, the neuron becomes depolarized. At Region 3, the neuron becomes repolarized.

(b) At Region 2 (depolarization), sodium ions are entering the neuron.

(c) At Region 3 (repolarization), potassium ions are leaving the neuron.

(d) At Regions 1 and 4 (resting membrane potential), the sodium ion concentration is higher outside than inside the neuron.

6. 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 the enzyme released into a synapse to break down acetylcholine. Breaking down acetylcholine removes it from the protein receptors, thus allowing the ion channels to close and the membrane to repolarize in a fraction of a second. One possible hypothesis is that if there is an overproduction of cholinesterase, acetylcholine will not be permitted to fulfill its function. This could affect muscle activity.

7. Neurotransmitters have either excitatory or inhibitory effects on the postsynaptic membrane. If the effect is excitatory, the receptor proteins will trigger ion channels that open to 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 will travel along the axon to the next neuron or effector.

If, however, the effect is inhibitory, 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 is no action potential.

8. **(a)** An action potential travels along an axon to the synaptic terminal. Synaptic vesicles move toward and fuse with the presynaptic membrane, releasing neurotransmitters into the synaptic cleft. Neurotransmitters bind to receptor proteins on the postsynaptic neuron and affect the movement of ions across the membrane, either causing an action potential or not. After the neurotransmitter has had its effect, enzymes inactivate it so that its components can be reabsorbed by the presynaptic cell. The postsynaptic neuron will then return to resting potential.

(b) Cocaine acts by blocking the re-uptake of certain neurotransmitters such as dopamine. By binding to the transporters that normally remove the excess of this neurotransmitter from the synaptic gap, cocaine prevents dopamine from being reabsorbed by presynaptic neurons, resulting in an increased concentration of dopamine in these synapses. As a result, the natural effect of dopamine on the postsynaptic neurons is amplified and produces the feeling of euphoria typically experienced by people who take cocaine.

(c) (Note: Students may be able to obtain some of this information from the group presentations or pamphlets on drugs from Thought Lab 11.1: The Effect of Drugs on Neurons and Synapses.) Dopamine has a number of roles. In terms of cocaine addiction, dopamine is commonly associated with the "pleasure system" of the brain, providing feelings of enjoyment and reinforcement to motivate us to do, or continue doing, certain activities. Students may also include the other roles that dopamine has in the brain. For example, dopamine is critical to the way the brain controls our movements. Shortage of dopamine causes Parkinson's disease, in which a person loses the ability to execute smooth, controlled movements. In the frontal lobes, dopamine controls the flow of information from other areas of the brain. Dopamine disorders in this region of the brain can cause a decline in cognitive functions, especially memory, attention and problem solving.

(d) From their research, students may hypothesize that cocaine causes extreme physical dependence because, with continued cocaine use, the body begins to make less dopamine to compensate for a seemingly endless supply. The user, therefore, experiences increased tolerance, withdrawal symptoms, and intense cravings for cocaine.