Chapter 9-4: The Nerve Impulse

The nervous system is responsible for directing the complex processes that take place in the body. It also links the body to the external environment and permits us to see, hear, taste, feel, and respond to stimuli.

Neurons are the cells of the nervous system and are specialized to receive and transmit information. As the structural and functional units of the nervous system, these cells are distinguished by their unique structure. In this plate, we study the structure of the neuron and the mechanism by which a nerve impulse is generated and propagated.

> The plate shows three diagrams: a diagram of a nerve cell, a diagram of a neuron at rest, and a diagram of the neuron during propagation of the action potential.

We begin the plate with our diagram of the neuron. This specialized cell bears several distinguishing characteristics. The **cell body (A)** is the main portion of the cell, and it has a **nucleus (B)** and other cellular organelles.

At one end of the neuron is a collection of extensions called **dendrites (C)**. In a multipolar neuron, nerve impulses enter the cell body through the dendrites. Extending away from the cell body is a long extension called the **axon (D)**. The nerve impulse sweeps down the axon from the cell body, as the arrows indicate. At the end of the axon are thousands of microscopic branches called **axon terminals (E)**. From these terminals, neurotransmitters are released, and transmit the nerve impulse to an adjoining neuron, muscle, or gland.

In many neurons, the axon is surrounded by cells called **Schwann cells (F)**. These cells are wrapped around axons and form **myelin sheaths (G)**, which enclose the axon. Myelin insulates the axon, which speeds up nerve impulses. Between successive Schwann cells there are gaps that are called **Nodes of Ranvier (H)**.

> Having discussed the structure of the neuron, we are ready to examine its activity. We begin by focusing on the diagram entitled Resting Potential. Continue coloring as before.

The nervous system coordinates stimulus and response through neural impulses. A neuron at rest is not transmitting an impulse and is said to have a resting potential. In neurons at rest, imbalances in electrical charges exist on either side of the cell membrane. **Sodium ions (I)** are actively pumped to the exterior by the process of active transport, and the excess of sodium ions outside the cell gives it a positive charge with respect to the cell cytosol. The number of **potassium ions (J)** in a resting cell is approximately equal inside and outside, but other negatively-charged ions accumulate in the cytoplasm, so that the outside of the cell bears a more positive charge than the inside. There is polarity across the cell membrane.

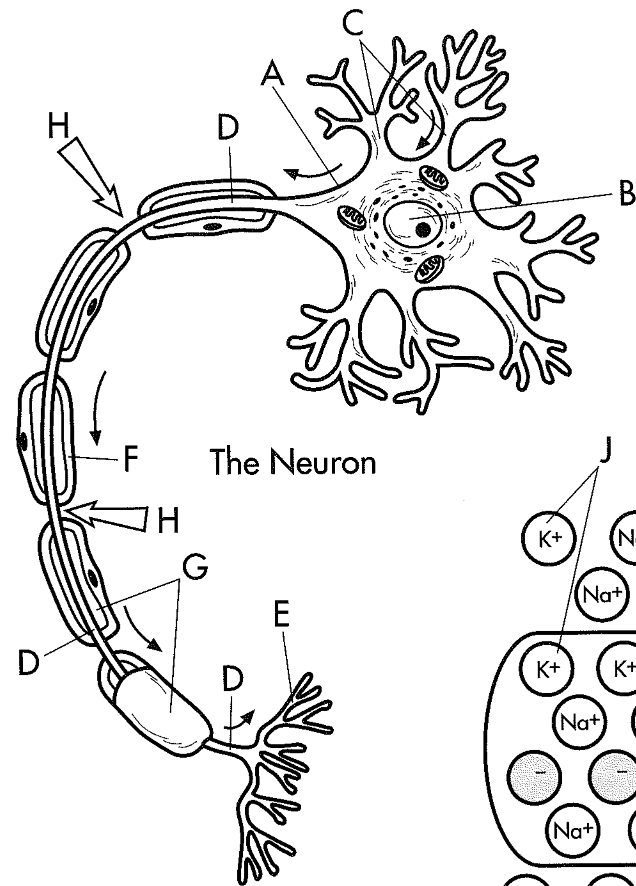
> We now return to the axon to see what happens when a nerve impulse arises. Focus on the diagram entitled Action Potential. Continue to color the diagram as you read below.

Nerve impulses are also called action potentials. Action potentials begin when an electrical, chemical, or mechanical stimulus alters the structure of the cell membrane, which allows sodium ions to enter. The sodium gates, which are ion channels, open, and as sodium ions rush into the cytoplasm, the membrane loses its polarity; it undergoes depolarization.

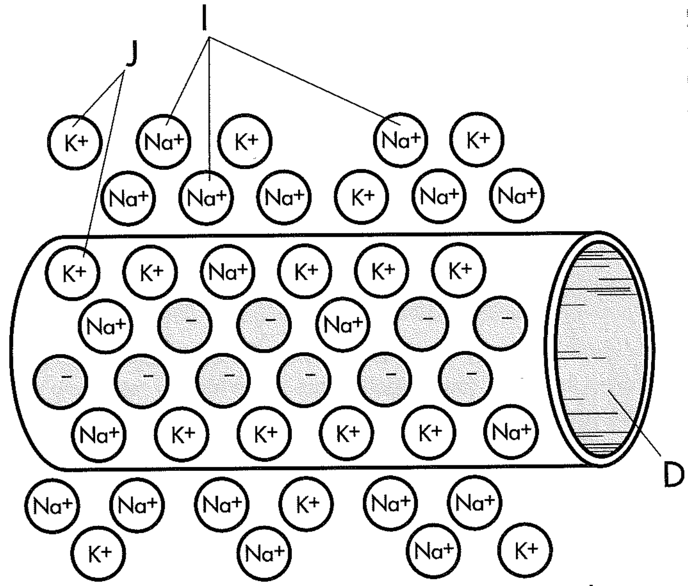
In the first diagram, we show a group of **inrushing sodium ions (M)**, indicated by the arrows. A stimulus has arrived and altered the membrane structure, which causes the propagation of an **action potential (nerve impulse) (L)**. The horizontal arrow shows the direction of this action potential. A momentary reversal of polarity around the cell membrane takes place, as the inside of the axon becomes more positively charged.

The action potential now depolarizes the adjacent area of the membrane, and in the second diagram the action potential is seen further to the right. In a chain reaction, the next area undergoes depolarization, as the third diagram shows. Sodium ions continue to rush into the cytoplasm of the axon at adjacent areas, and a wave of depolarization sweeps down the axon of the neuron.

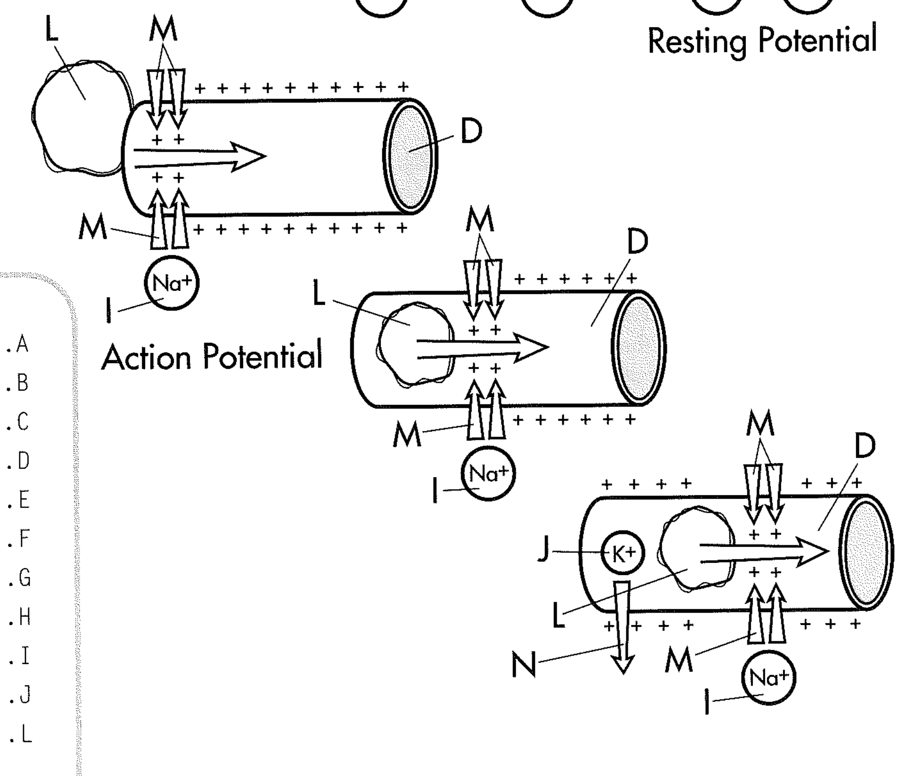
After the action potential has passed, the membrane repolarizes, the sodium gates close, and the potassium gates open, which allows potassium ions to move out of the cytoplasm. In the third diagram we see **outrushing potassium ions (N)**, which return the external area to a positive state (repolarizing the membrane) so that another nerve impulse can occur. If no nerve impulse is immediately forthcoming, the cell pumps sodium to the exterior to reestablish the conditions seen in the resting potential. The entire depolarization and repolarization of the neuron occurs in less than a millisecond.



The Neuron



Resting Potential



Action Potential

The Nerve Impulse

- ○ Cell Body ....A
- ○ Nucleus................B
- ○ Dendrites..............C
- ○ Axon ....D
- ○ Axon Terminals ....E
- ○ Schwann Cell ....F
- ○ Myelin Sheath..........G
- ○ Node of Ranvier........H
- ○ Sodium Ions............I
- ○ Potassium Ions ....J
- ○ Action Potential L
- ○ Inrushing Sodium Ions ....M
- ○ Outrushing Potassium Ions ....N