

Intracellular Recording

Application: Electrophysiologists use intracellular recording to measure the membrane potential of neurons and other cells.

Technique: A microelectrode is made from a glass capillary tube filled with an electrically conductive salt solution. One end of the tube tapers to an extremely fine tip (diameter < 1 μm). While looking through a microscope, the experimenter uses a micropositioner to insert the tip of the microelectrode into a cell. A voltage recorder (usually an oscilloscope or a computer-based system) measures the voltage between the microelectrode tip inside the cell and a reference electrode placed in the solution outside the cell.



to that of K^+ (see Table 48.1). Na^+ therefore diffuses into the cell, making the inside of the cell less negative. If we model a membrane in which the only open channels are selectively permeable to Na^+ , we find that a tenfold higher concentration of Na^+ in the outer chamber results in an equilibrium potential (E_{Na}) of +62 mV (Figure 48.7b). In an actual neuron, the resting potential (−60 to −80 mV) is much closer to E_K than to E_{Na} because there are many open potassium channels but only a small number of open sodium channels.

Because neither K^+ nor Na^+ is at equilibrium in a resting neuron, there is a net flow of each ion (a current) across the membrane. The resting potential remains steady, which means that the K^+ and Na^+ currents are equal and opposite. Ion concentrations on either side of the membrane also remain steady. Why? The resting potential arises from the net movement of far fewer ions than would be required to alter the concentration gradients.

Under conditions that allow Na^+ to cross the membrane more readily, the membrane potential will move toward E_{Na} and away from E_K . As you'll see in the next section, this is precisely what happens during the generation of a nerve impulse.

CONCEPT CHECK 48.2

- Under what circumstances could ions flow through an ion channel from a region of lower ion concentration to a region of higher ion concentration?
- WHAT IF?** Suppose a cell's membrane potential shifts from −70 mV to −50 mV. What changes in the cell's permeability to K^+ or Na^+ could cause such a shift?
- MAKE CONNECTIONS** Review Figure 7.10, which illustrates the diffusion of dye molecules across a membrane. Could diffusion eliminate the concentration gradient of a dye that has a net charge? Explain.

For suggested answers, see Appendix A.

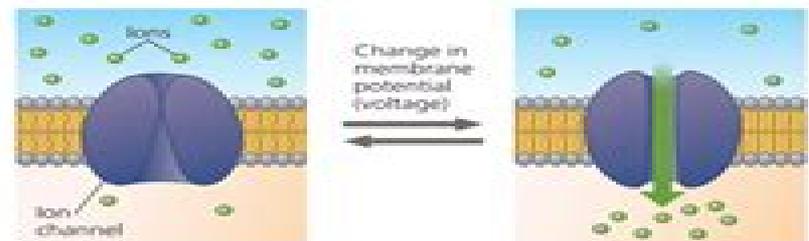
CONCEPT 48.3

Action potentials are the signals conducted by axons

When a neuron responds to a stimulus, such as the scent of fish detected by a hunting cone snail, the membrane potential changes. Using the technique of intracellular recording, researchers can record these changes as a function of time (Figure 48.8). Changes in the membrane potential occur because neurons contain **gated ion channels**, ion channels that open or close in response to stimuli. The opening or closing of gated ion channels alters the membrane's permeability to particular ions, which in turn alters the membrane potential.

Hyperpolarization and Depolarization

When gated ion channels are stimulated to open, ions flow across the membrane, changing the membrane potential (Figure 48.9). For example, opening gated potassium channels in a resting neuron increases the membrane's permeability to K^+ . Net diffusion of K^+ out of the neuron increases, shifting the membrane potential toward E_K (−90 mV at 37°C). This increase in the magnitude of the membrane potential, called a **hyperpolarization**, makes the inside of the membrane more negative (Figure 48.10a). In a resting neuron, hyperpolarization results from any stimulus that increases the outflow of positive ions or the inflow of negative ions.



Gate closed: No ions flow across membrane.

Gate open: Ions flow through channel.

▲ Figure 48.9 Voltage-gated ion channel. A change in the membrane potential in one direction (indicated by the right-pointing arrow) opens the voltage-gated channel. The opposite change (left-pointing arrow) closes the channel.

48 Neurons Synapses And Signaling Guide Answers

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