Topic 4.1

Cell Communication

Learning Objectives

- Learn the mechanisms by which cells communicate with other cells
- Understand how cells can communicate with other cells over short and long distances

Topic Questions

- What are the main types of communication that occur between cells?
- How do cells communicate with other nearby cells?
- How does a cell communicate with other cells located relatively far from the signaling cell?

4.1.01 Mechanisms of Cell Communication

[IST-3.A.1]

One characteristic common to all living cells is the ability to detect and respond to various stimuli (ie, signals) in the environment. This ability allows cells to detect necessary resources, avoid harmful conditions, and communicate with other cells. Because cells can communicate with each other, cellular activities can be coordinated among different cells, including among different cell types making up a multicellular organism as well as within groups of single-celled (ie, unicellular) organisms (eg, bacteria, yeast). Cell communication has been observed to occur in all organism types, including prokaryotes and eukaryotes.

Although the specific steps involved in cell communication vary among different kinds of cells, there are two general **mechanisms of cell communication**: direct **cell-to-cell contact** and communication over a distance using **chemical signals**. These two general mechanisms are shown in Figure 4.1.

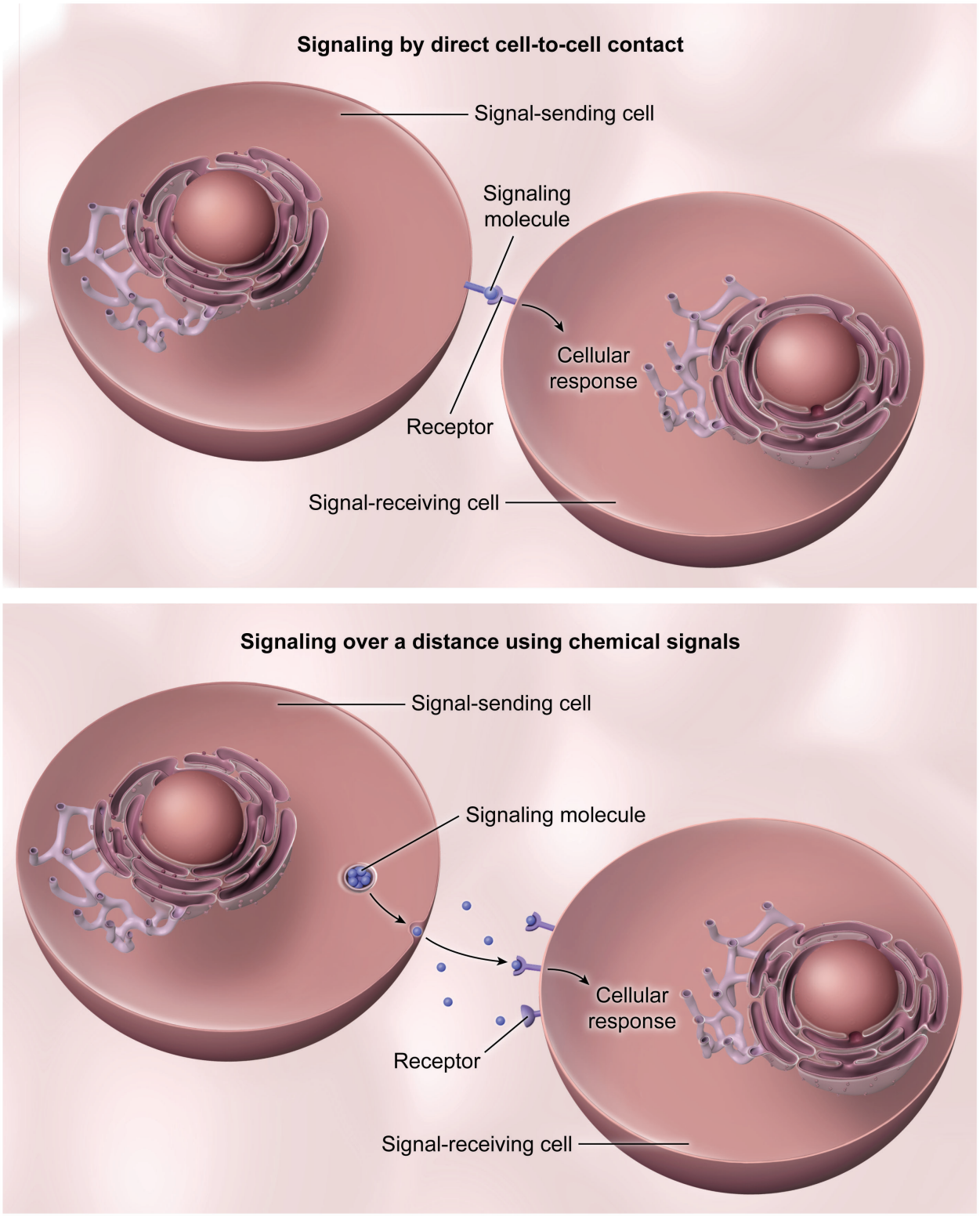

Figure 4.1 General mechanisms of cell communication.

4.1.02 Cell Communication via Cell-to-Cell Contact

[IST-3.A.1]

Cell communication involving cell-to-cell contact can occur in different ways. In one type of communication involving direct contact between cells, signaling molecules (typically proteins) on the surface of a signal-sending cell interact with receptors on the surface of a signal-receiving cell, stimulating a cellular response in the receiving cell. Among other uses, this type of cell-to-cell communication plays an important role in the function of animal immune systems. Figure 4.2 shows an example of cell-to-cell communication between two types of immune cells.

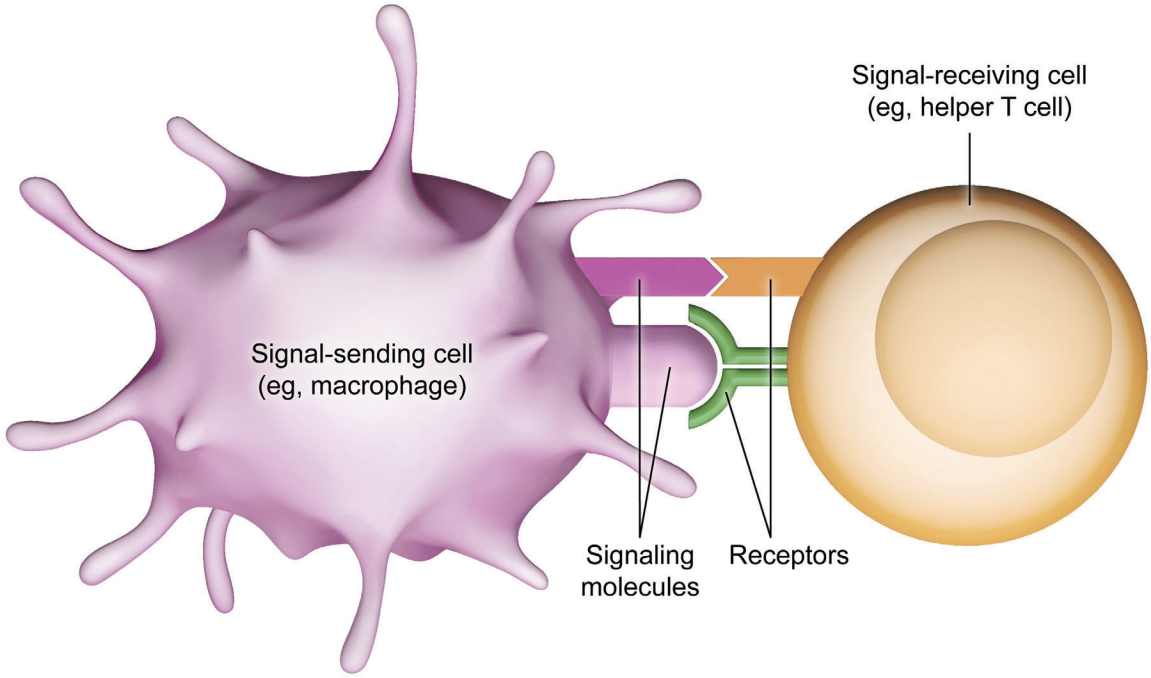

Figure 4.2 Communication by direct contact between immune system cells.

Cell communication can also occur when signaling molecules pass directly from cell to cell through specialized cell junctions in multicellular organisms. In animals, cells can be joined by structures called **gap junctions**, which allow small molecules and ions that function in cell signaling to pass directly and rapidly from cell to cell. Gap junctions are typically found in tissues that need to coordinate their activities to function as a unit, such as the muscle cells that make up the heart.

In plants, cells can be joined by structures called **plasmodesmata**, which consist of plasma membrane–lined channels that extend through the cell walls of adjacent cells, forming direct connections between the cytoplasm of each cell. In addition to allowing the passage of small signaling molecules (such as those that pass through animal cell gap junctions), plasmodesmata allow larger signaling molecules, such as proteins and RNA molecules, to pass directly from cell to cell. Figure 4.3 shows how gap junctions and plasmodesmata function in cell-to-cell communication.

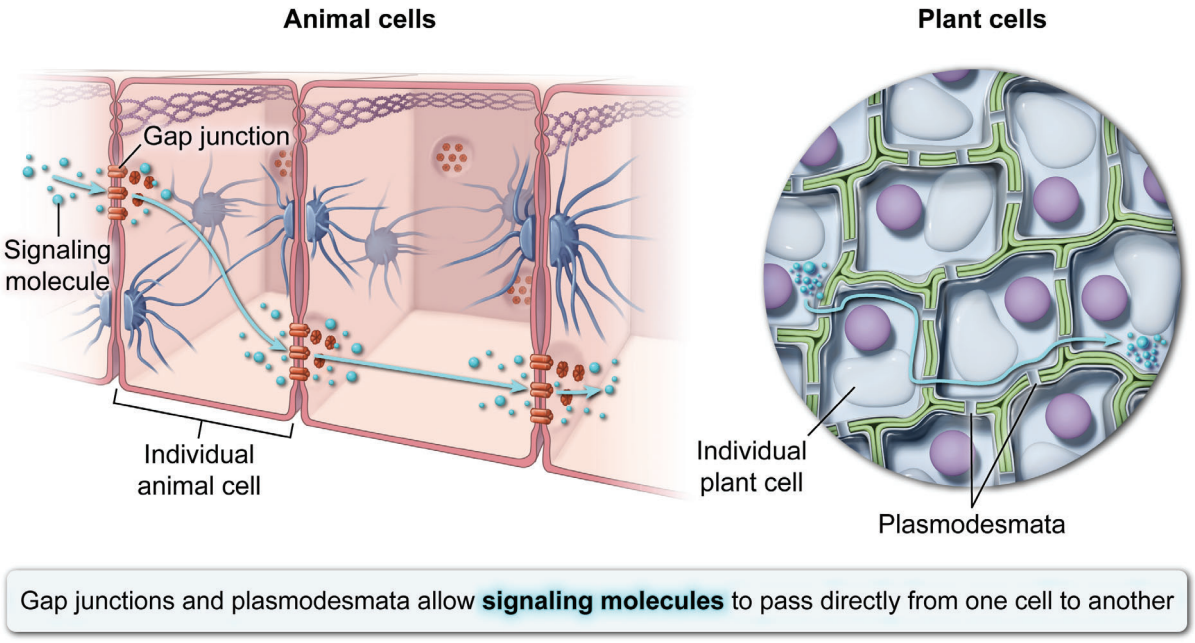

Figure 4.3 Cell-to-cell communication through gap junctions and plasmodesmata.

4.1.03 Short Distance Cell Communication via Local Regulators

[IST-3.B.1]

In addition to cell communication that involves direct cell-to-cell contact, cells can communicate with other nearby cells (with which they are not in direct contact) through the release of chemical signaling molecules called **local regulators**. Local regulators quickly diffuse through fluid surrounding the cells (ie, interstitial fluid) to reach nearby target cells. The target cells have specific **receptors** to which the signaling molecules bind, setting off a cellular response. This type of cell communication is important in many biological processes, including embryonic development and the functioning of the nervous system.

In some cases, local regulators can cause responses to occur in the same cells that release them. In this way, cells can influence their own activity by releasing signaling molecules that bind to the signal-sending cell's own receptors. Figure 4.4 shows how cells can communicate with themselves or with nearby cells using local regulators.

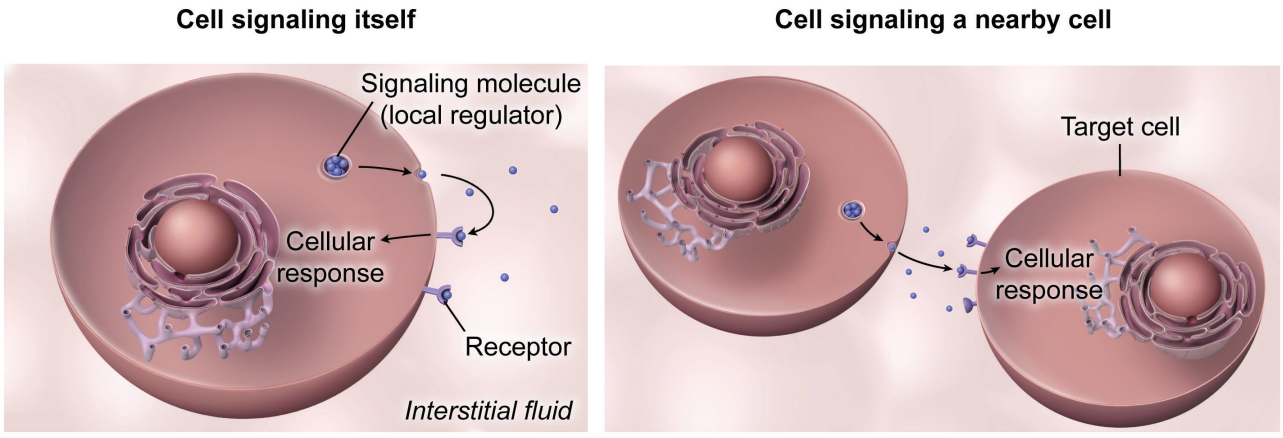

Figure 4.4 Cell communication through the release of local regulators.

4.1.04 Long-Distance Communication between Different Cell Types

[IST-3.B.1]

Long-distance cell communication occurs in multicellular organisms and involves the release of signaling molecules that travel from cells in one part of the organism to target cells of a different type located in other parts of the organism. This type of long-distance cell communication typically requires a specialized transport system (eg, animal circulatory system, plant vascular system) to send signaling molecules to target cells. These specialized transport systems are necessary because diffusion (which is responsible for transport of local regulators) is a very slow means of moving substances over long distances.

In both animals and plants, long-distance signaling uses signaling molecules called **hormones**. In animals, hormones are transported in the blood of the animal's circulatory system. Plant hormones, which are also known as plant growth regulators, can be transported in specialized plant tissues (ie, vascular tissues) as well as from cell to cell through plasmodesmata. Similar to the mechanism described for local regulators in Sub-Topic 4.1.03, hormones bind to receptors on target cells to stimulate cellular responses. Figure 4.5 shows an example of long-distance hormonal signaling in animals.

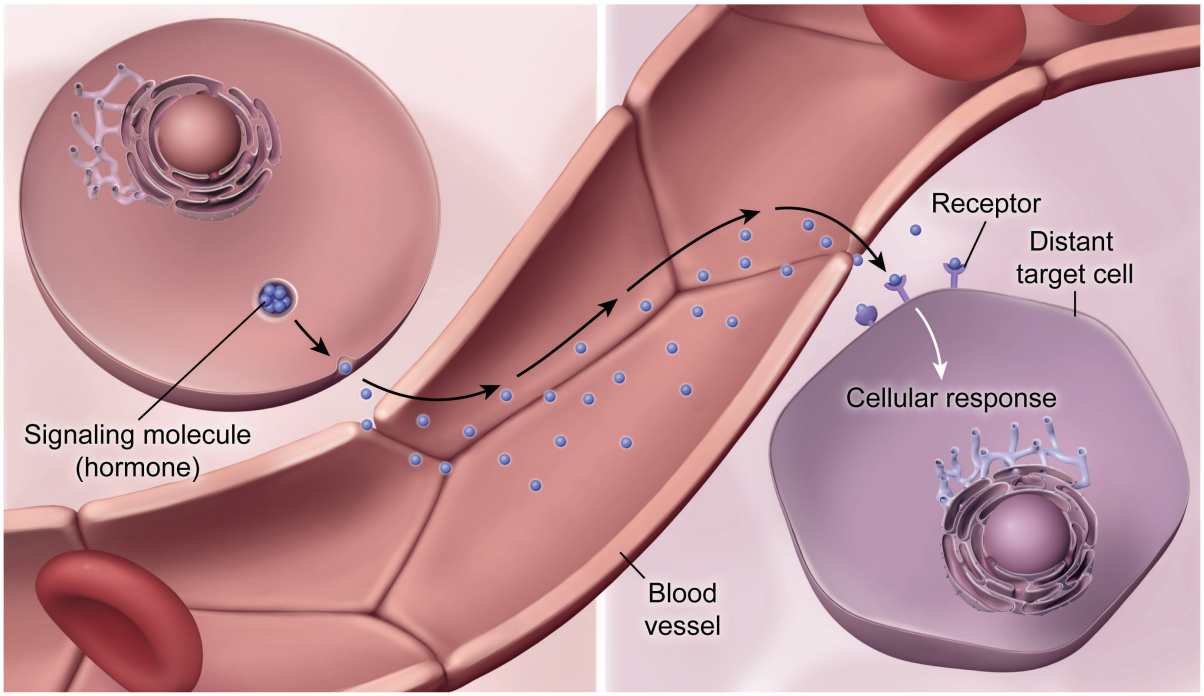

Figure 4.5 Long-distance cell communication involving an animal hormone.

Hormonal signaling is used extensively in multicellular organisms to regulate many biological processes, including growth, metabolism, reproduction, and the maintenance of a relatively stable set of internal conditions (ie, homeostasis).

Topic 4.1 Cell Communication
Check for Understanding Quiz

1. Which of the following best describes how cells communicate via local regulators?
   A. Signaling molecules on the surface of one cell interact with receptors on the surface of another cell.
   B. Signaling molecules released by one cell diffuse through interstitial fluid to reach nearby target cells.
   C. Small and large molecules pass directly from cell to cell through plasmodesmata.
   D. Small molecules and ions pass directly and rapidly from cell to cell through gap junctions.

2. Which of the following statements regarding long-distance cell communication is FALSE?
   A. Long-distance cell communication is accomplished using signaling molecules called hormones.
   B. Long-distance cell communication occurs extensively in animals but is not utilized by plants.
   C. Long-distance cell communication is used to regulate growth and reproduction in multicellular organisms.
   D. Long-distance cell communication requires a specialized transport system to deliver signaling molecules to target cells.

Note: Answers to this quiz are in the back of the book (appendix).