# 3.3 Cell Membrane

**KEY CONCEPT** The cell membrane is a barrier that separates a cell from the external environment.

**MAIN IDEAS**

- Cell membranes are composed of two phospholipid layers.
- Chemical signals are transmitted across the cell membrane.

**VOCABULARY**

**cell membrane,** p. 81
**phospholipid,** p. 81
**fluid mosaic model,** p. 82
**selective permeability,** p. 83
**receptor,** p. 84

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***Connect*** Think about how the products you buy are packaged—a pint of berries, perhaps, or a tube of toothpaste. The berries are probably in a plastic container that has holes to allow air circulation. The toothpaste is in a tube strong enough to be squeezed without ripping. Both containers protect their contents, but they do so in different ways. Like these products, the cell needs protection, but it must also be able to respond to its surroundings. It is constantly taking in and getting rid of various molecules. The structure of the cell membrane allows it to perform all those functions.

MAIN IDEA

## Cell membranes are composed of two phospholipid layers.

The **cell membrane,** or the plasma membrane, forms a boundary between a cell and the outside environment and controls the passage of materials into and out of a cell. The cell membrane consists of a double layer of phospholipids interspersed with a variety of other molecules. A **phospholipid** (FAHS-foh-LIHP-ihd) is a molecule composed of three basic parts:

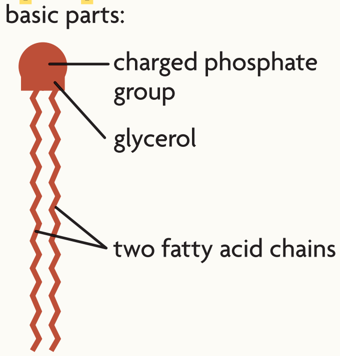
- a charged phosphate group
- glycerol
- two fatty acid chains

Together, the glycerol and the phosphate groups form the "head" of a phospholipid; the fatty acids form the "tail." Because the head bears a charge, it is polar. Recall that water molecules are also polar. Therefore, the polar head of the phospholipid forms hydrogen bonds with water molecules. In contrast, the fatty acid tails are nonpolar and cannot form hydrogen bonds with water. As a result, the nonpolar tails are attracted to each other and repelled by water.

Because the membrane touches the cytoplasm inside the cell and the watery fluid outside the cell, the properties of polar heads and nonpolar tails cause the phospholipids to arrange themselves in layers, like a sandwich.

**VISUAL VOCAB**

A **phospholipid** is composed of three basic parts:




***Connecting* CONCEPTS**

**Biochemistry** Recall from **Chapter 2** that a hydrogen bond is a weak chemical bond that forms between a slightly positive hydrogen atom and a negatively charged region of another molecule.

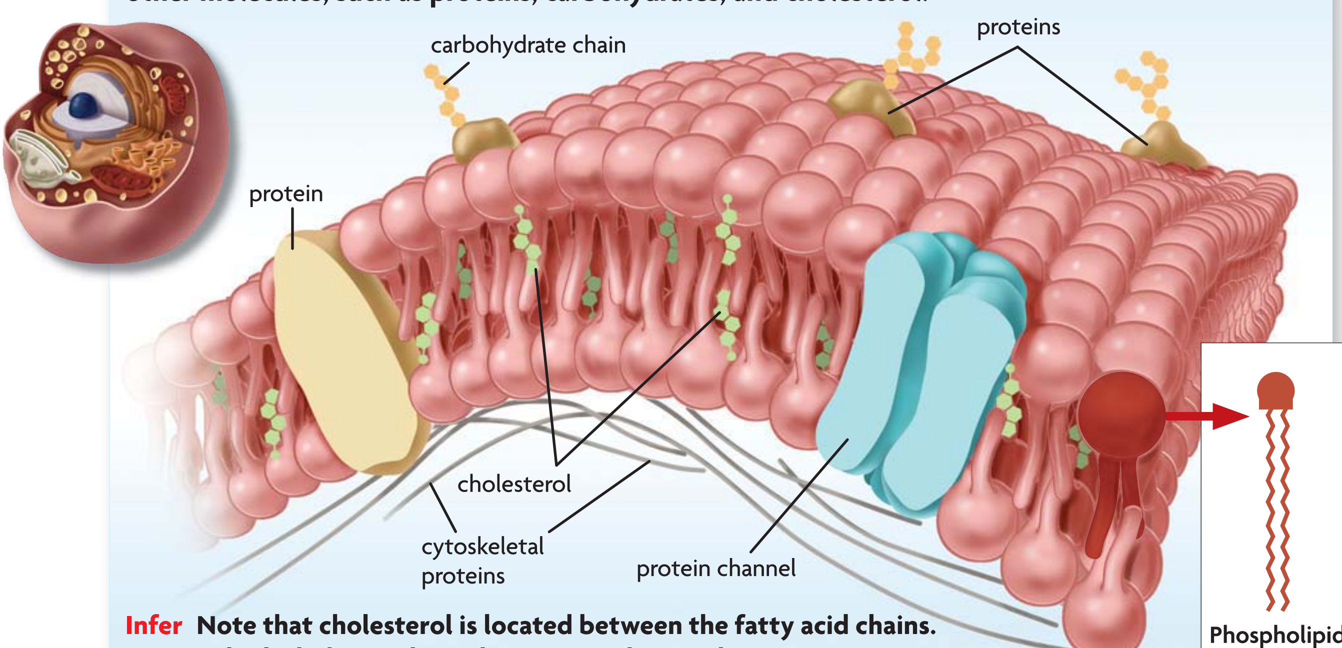
The polar heads are like the bread. They form the outer surfaces of the membrane, where they interact with the watery environment both outside and inside a cell. The nonpolar tails are like the filling. They are sandwiched between the layers of polar heads, where they are protected from the watery environment.

**FIGURE 3.17** shows other molecules embedded within the phospholipid layers. They give the membrane properties and characteristics it would not otherwise have. These molecules serve diverse functions. Here are a few examples:

- Cholesterol molecules strengthen the cell membrane.
- Some proteins extend through one or both phospholipid layers and help materials cross the membrane. Other proteins are key components of the cytoskeleton. Different cell types have different membrane proteins.
- Carbohydrates attached to membrane proteins serve as identification tags, enabling cells to distinguish one type of cell from another.

**FIGURE 3.17 Cell Membrane**

**The cell membrane is made of two phospholipid layers embedded with other molecules, such as proteins, carbohydrates, and cholesterol.**




**Infer Note that cholesterol is located between the fatty acid chains. Do you think cholesterol is polar or nonpolar? Explain your answer.**

## Fluid Mosaic Model

Scientists have developed the **fluid mosaic model,** which describes the arrangement of the molecules that make up a cell membrane. This model of cell membrane structure takes its name from two characteristics. First, the cell membrane is flexible, not rigid. The phospholipids in each layer can move from side to side and slide past each other. As a result, the membrane behaves like a fluid, similar to a film of oil on the surface of water. However, proteins embedded in the membrane do not flip vertically. If one part of a protein is outside the membrane, it will stay outside the membrane. Second, the variety of molecules studding the membrane is similar to the arrangement of colorful tiles with different textures and patterns that make up a dynamic mosaic.

**QUICK LAB** **MODELING**

## Modeling the Cell Membrane

The cell membrane regulates what moves into and out of the cell.

**PROBLEM** How does the cell membrane regulate what moves into and out of the cells?

**PROCEDURE**

1. Bundle the swabs as shown.
2. Make a receptor from one pipe cleaner. It should extend through the bunch of swabs and have a region that would bind to a signal molecule. Use the other pipe cleaner to make a carbohydrate chain. Insert the chain into the "membrane" of the bunch of swabs.
3. Cut the drinking straw in half and insert both halves into the bunch of swabs.

**ANALYZE AND CONCLUDE**

1. **Explain** How do the swabs represent the polar and nonpolar characteristics of the cell membrane?
2. **Apply** In this model, the swabs and proteins can be moved around. Explain whether this is an accurate representation of actual cell membranes.

**MATERIALS**

- 50 cotton swabs
- 1 thick medium-sized rubber band
- 2 pipe cleaners, each a different color
- 1 drinking straw
- scissors

### Selective Permeability

The cell membrane has the property of **selective permeability,** which means it allows some, but not all, materials to cross. Selective permeability is illustrated in **FIGURE 3.18.** The terms *semipermeable* and *selectively permeable* also refer to this property. As an example, outdoor clothing is often made of semipermeable fabric. The material is waterproof yet breathable. Molecules of water vapor from sweat are small enough to exit the fabric, but water droplets are too large to enter.

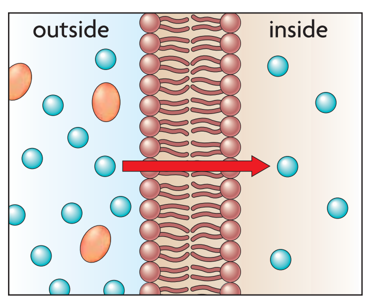



**FIGURE 3.18** A selectively permeable membrane allows some, but not all, molecules to cross.

Selective permeability enables a cell to maintain homeostasis in spite of unpredictable, changing conditions outside the cell. Because a cell needs to maintain certain conditions to carry out its functions, it must control the import and export of certain molecules and ions. Thus, even if ion concentrations change drastically outside a cell, these ions won't necessarily interfere with vital chemical reactions inside a cell.

Molecules cross the membrane in several ways. Some of these methods require the cell to expend energy; others do not. How a particular molecule crosses the membrane depends on the molecule's size, polarity, and concentration inside versus outside the cell. In general, small nonpolar molecules easily pass through the cell membrane, small polar molecules are transported via proteins, and large molecules are moved in vesicles.

**Connect** **Describe a semipermeable membrane with which you are already familiar.**

***Connecting* CONCEPTS**

**Homeostasis** Recall from **Chapter 1** that homeostasis must be maintained in all organisms because vital chemical reactions can take place only within a limited range of conditions.

MAIN IDEA

## Chemical signals are transmitted across the cell membrane.

Recall that cell membranes may secrete molecules and may contain identifying molecules, such as carbohydrates. All these molecules can act as signals to communicate with other cells. How are these signals recognized?

A **receptor** is a protein that detects a signal molecule and performs an action in response. It recognizes and binds to only certain molecules, which ensures that the right cell gets the right signal at the right time. The molecule a receptor binds to is called a ligand. When a receptor and a ligand bind, they change shape. This change is critical because it affects how a receptor interacts with other molecules. Two major types of receptors are present in your cells.

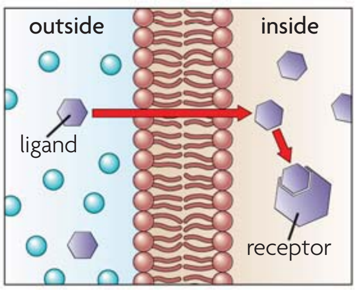



**FIGURE 3.19** Intracellular receptors are located inside the cell. They are bound by molecules that can cross the membrane.

### Intracellular Receptor

A molecule may cross the cell membrane and bind to an intracellular receptor, as shown in **FIGURE 3.19.** *Intracellular* means "within, or inside, a cell." Molecules that cross the membrane are generally nonpolar and may be relatively small. Many hormones fit within this category. For example, aldosterone can cross most cell membranes. However, it produces an effect only in cells that have the right type of receptor, such as kidney cells. When aldosterone enters a kidney cell, it binds to an intracellular receptor. The receptor-ligand complex enters the nucleus, interacts with the DNA, and turns on certain genes. As a result, specific proteins are made that help the kidneys absorb sodium ions and retain water, both of which are important for maintaining normal blood pressure.

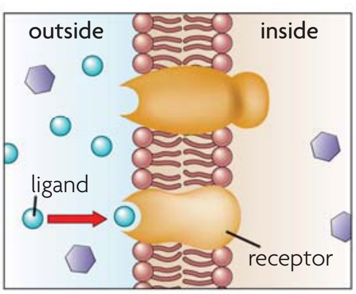



**FIGURE 3.20** Membrane receptors bind to molecules that cannot enter the cell. When bound, the receptor transmits the signal inside the cell by changing shape.

### Membrane Receptor

A molecule that cannot cross the membrane may bind to a receptor in the cell membrane, as shown in **FIGURE 3.20.** The receptor then sends the message to the cell interior. Although the receptor binds to a signal molecule outside the cell, the entire receptor changes shape—even the part inside the cell. As a result, it causes molecules inside the cell to respond. These molecules, in turn, start a complicated chain of events inside the cell that tells the cell what to do. For instance, band 3 protein is a membrane receptor in red blood cells. When activated, it triggers processes that carry carbon dioxide from body tissues to the lungs.

**Contrast** **How do intracellular receptors differ from membrane receptors?**

## 3.3 ASSESSMENT

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### REVIEWING MAIN IDEAS

1. Why do **phospholipids** form a double layer?
2. Explain how membrane **receptors** transmit messages across the **cell membrane.**

### CRITICAL THINKING

3. **Compare** Describe the similarities between enzymes and receptors.
4. **Infer** If proteins were rigid, why would they make poor receptors?

### Connecting CONCEPTS

5. **Human Biology** Insulin helps cells take up sugar from the blood. Explain the effect on blood sugar levels if insulin receptors stopped working.