## Cell Membrane Proteins: Functional Elements

The lipid bilayer determines the basic structure of the cell membrane, but the various functions of the membrane are carried out by the membrane proteins. Some protein molecules that span the membrane are glycoproteins having attached carbohydrate chains that face outward. Other proteins are located on the internal surface of the membrane, where they are held in place by cytoskeleton filaments.

The proteins of the membrane carry out various functions (fig. 4.2). Cell-recognition proteins are glycoproteins unique to the cell. They make up a cellular fingerprint by which cells can recognize one another. As we will discuss in more detail, certain proteins are involved in the passage of molecules through the membrane. Some proteins have a *channel* through which an ion or molecule can simply move across the membrane; others are *carriers*, which combine with a substance and help it to move across the membrane. Still other proteins are *receptors*; each type of receptor has a specific shape, which allows a particular molecule to bind to it. The binding of a molecule, such as a hormone, can influence the metabolism of the cell. Viruses often must attach to receptors before they enter a cell. Some proteins have an *enzymatic function* and carry out metabolic reactions.

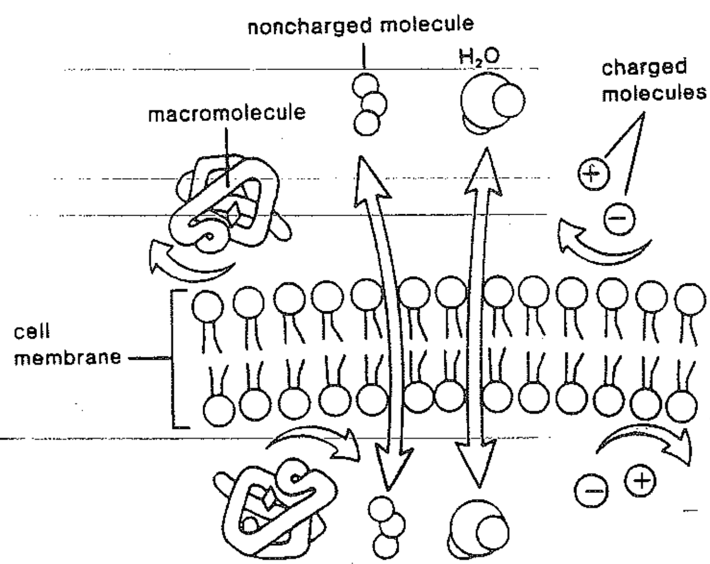
All cells are surrounded by a cell membrane. The cell membrane is composed of a phospholipid bilayer in which proteins having various functions are embedded. Do 4.1 Critical Thinking, found at the end of the chapter.

**Table 4.1**
Passage of Molecules into and out of Cells

| | Name | Direction | Requirements | Examples |
|---|---|---|---|---|
| *Passive Transport Means* | Simple Diffusion | Toward lower concentration | Concentration gradient | Lipid-soluble molecules, water, and gases |
| | Facilitated Diffusion | Toward lower concentration | Carrier and concentration gradient | Sugars and amino acids |
| *Active Transport Means* | Active Transport | Toward greater concentration | Carrier plus energy | Sugars, amino acids, and ions |
| | Endocytosis | | | |
| | Phagocytosis | Toward inside | Vesicle formation | Cells and subcellular material |
| | Pinocytosis | Toward inside | Vesicle formation | Macromolecules |
| | Exocytosis | Toward outside | Vesicle fuses with cell membrane | Macromolecules |

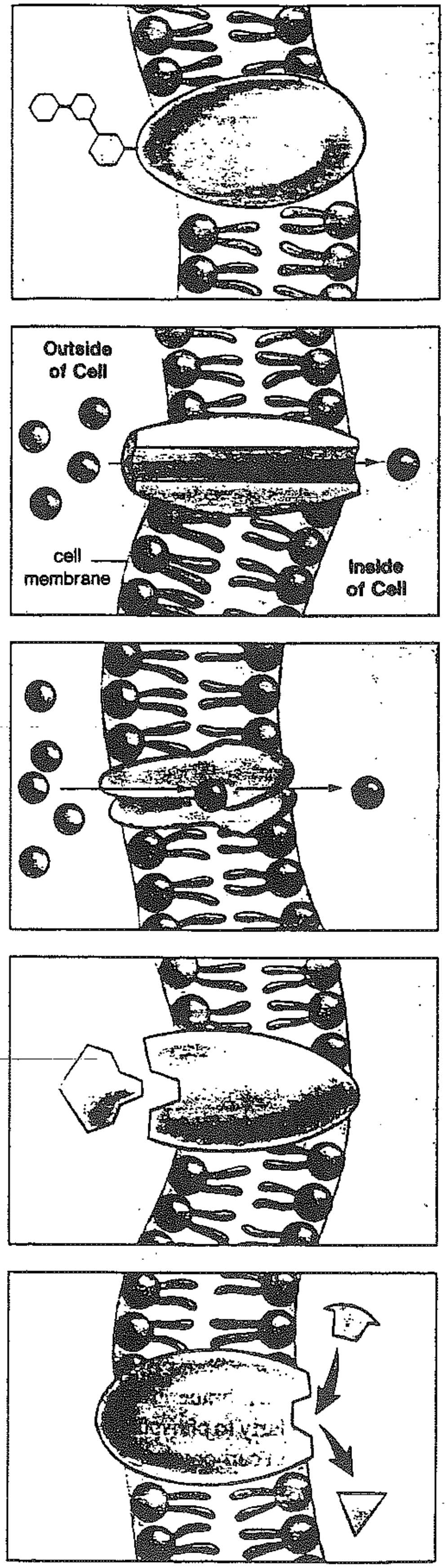
## How Molecules Cross the Membrane

In order for molecules to enter and exit the cell, they must cross the cell membrane. The structure of the cell membrane affects which types of molecules can freely pass through it. Small noncharged molecules, particularly if they are lipid soluble, have no difficulty crossing the membrane. Macromolecules cannot freely cross a cell membrane, and charged ions and molecules have difficulty. The membrane is usually positively charged outside and negatively charged inside. (Negatively charged ions tend to move through channels from inside the cell to outside the cell, and positively charged ions tend to move [through channels] in the opposite direction.) Because passage is restricted, the cell membrane is said to be **differentially permeable** (or selectively permeable).




There are both passive and active ways of assisting the passage of molecules across the cell membrane. The active ways use energy (ATP molecules), while the passive ways do not. The *passive ways* involve diffusion, both simple and facilitated, and the *active ways* involve active transport, endocytosis, and exocytosis (table 4.1).

**Figure 4.2**
Membrane protein diversity. These are some of the functions performed by proteins found in the cell membrane.




Cell-recognition protein

A glycoprotein that identifies the cell. For example, the MHC (major histocompatibility complex) glycoproteins are different for each person; thus, organ transplants are risky and relatively infrequent. Cells with foreign MHC glycoproteins are attacked by blood cells responsible for immunity.

Channel protein

A protein that allows a particular molecule or ion to freely cross the cell membrane as it enters or exits the cell. Recently, it has been shown that cystic fibrosis, an inherited disorder, is caused by faulty chloride ion ($Cl^-$) channels. When these channels are not functioning normally, a thick mucus collects in airways and in pancreatic and liver ducts.

Carrier protein

A protein that selectively interacts with a specific molecule or ion so that it can cross the cell membrane to enter or exit the cell. The carrier protein that transports sodium ions ($Na^+$) and potassium ions ($K^+$) across the cell membrane requires ATP energy. The inability of some persons to use up energy for sodium-potassium transport has been suggested as the cause of their obesity.

Receptor protein

A protein that is shaped in such a way that a specific molecule can bind to it. Recently, it has been shown that Pygmies are short not because they do not produce enough growth hormone, but because their cell membrane growth hormone receptors are faulty and cannot interact with the hormone.

Enzymatic protein

A protein that catalyzes a specific reaction. For example, adenylate cyclase is a cell membrane protein that is involved in ATP metabolism. Polluted water may contain cholera bacteria, which release a toxin that interferes with the proper function of adenylate cyclase. Sodium ions and water leave intestinal cells in such volume that the individual dies from severe diarrhea.

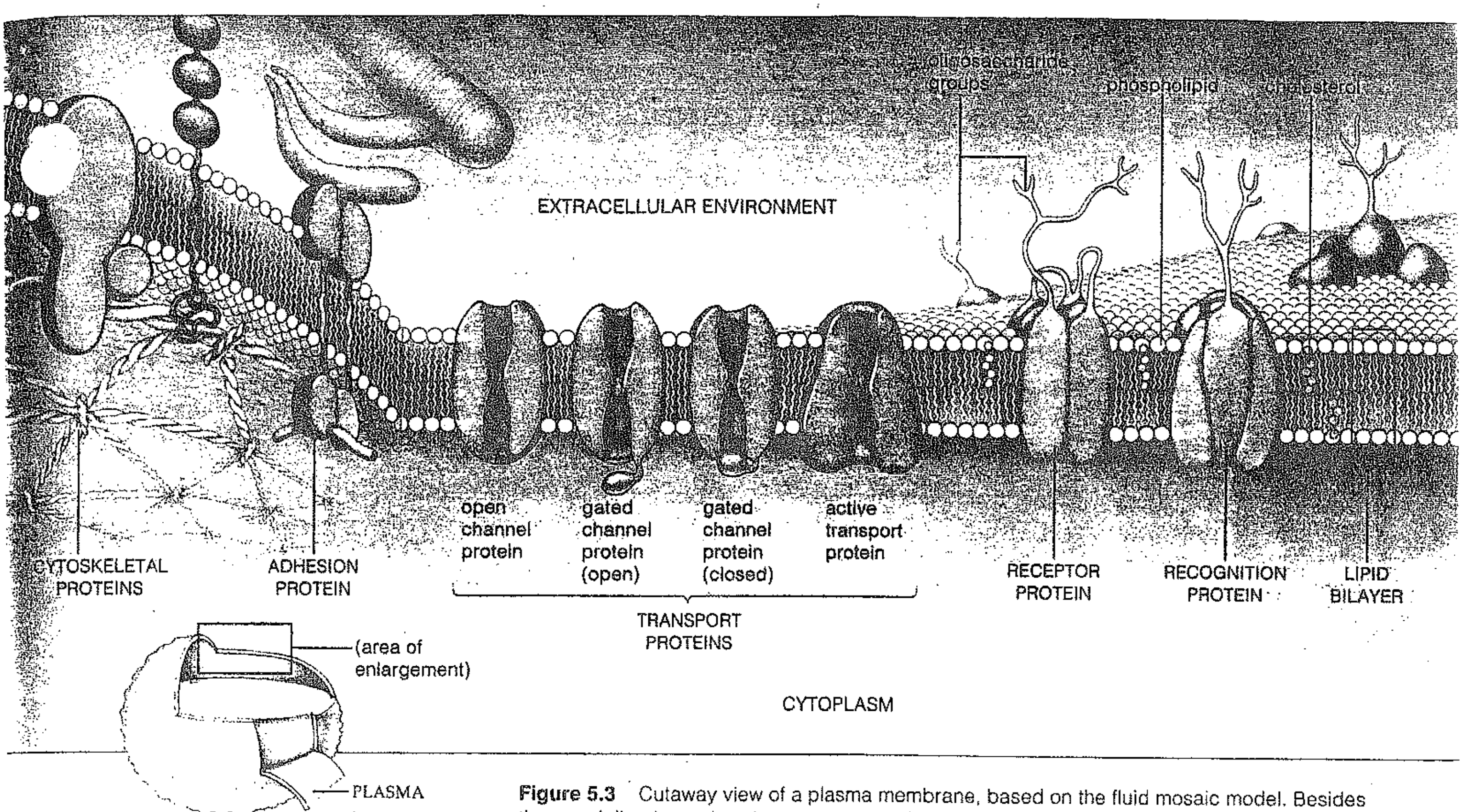



**Figure 5.3** Cutaway view of a plasma membrane, based on the fluid mosaic model. Besides the specialized proteins shown, enzymes also are associated with cell membranes.

.'he hydrophobic interactions that give rise to most of a membrane's structure are weaker than covalent bonds. This means most phospholipids and some proteins are free to drift sideways. Also, the phospholipids can spin about their long axis and flex their tails, which keeps neighboring molecules from packing together in a solid layer. Short or kinked (unsaturated) fatty acid tails also contribute to membrane fluidity.

The fluid mosaic model is a good starting point for exploring cell membranes. But bear in mind, membranes differ in the details of their molecular composition and arrangements, and they are not even the same on both surfaces of their bilayer. For example, oligosaccharides and other carbohydrates are covalently bonded to protein and lipid components of a plasma membrane, but only on its outward-facing surface (Figure 5.3). Moreover, they differ in number and kind from one species to the next, even among the different cells of the same individual.

## *Overview of Membrane Proteins*

The proteins embedded in a lipid bilayer or attached to one of its surfaces carry out most membrane functions. Many are enzyme components of metabolic machinery. Others are **transport proteins** that allow water-soluble ıbstances to move through their interior, which spans ..e bilayer. They bind molecules or ions on one side of the membrane, then release them on the other side.

The **receptor proteins** bind extracellular substances, such as hormones, that trigger changes in cell activities. For example, certain enzymes that crank up machinery for cell growth and division become switched on when somatotropin, a hormone, binds with receptors for it. Different cells have different combinations of receptors.

Diverse **recognition proteins** at the cell surface are like molecular fingerprints; their oligosaccharide chains identify a cell as being of a specific type. For example, "self" proteins pepper the plasma membrane of your cells. Certain white blood cells chemically recognize the proteins and leave your own cells alone, but they attack invading bacterial cells having "nonself" proteins at their surface. Finally, **adhesion proteins** of multicelled organisms help cells of the same type locate and stick to one another and stay positioned in the proper tissues. They are glycoproteins with oligosaccharides attached. After tissues form, the sites of adhesion may become a type of cell junction, as described earlier in Section 4.10.

**A cell membrane has two layers composed mainly of lipids, phospholipids especially. This lipid bilayer is the structural foundation for the membrane and also serves as a barrier to water-soluble substances.**

**Hydrophilic heads of the phospholipids are dissolved in fluids that bathe the two outer surfaces of the bilayer. Their hydrophobic tails are sandwiched between the heads.**

**Proteins associated with the bilayer carry out most membrane functions. Many are enzymes, transporters of substances across the bilayer, or receptors for extracellular substances. Other types function in cell-to-cell recognition or adhesion.**