Chapter 5: Structure and Function of the Cell Membrane and an Introduction to Energy

Figure 5.1 A hummingbird needs energy to maintain prolonged flight. (credit: modification of work by Cory Zanker / Biology 2E OpenStax)

Virtually every task performed by living organisms requires energy. For humans, energy is needed to exercise, to think, and even during sleep. Plants need energy to perform photosynthesis, cell division, and metabolism. Protists use energy to expel excess water and power their cilia. All living cells continuously use energy.

From where, and in what form, does this energy come? How do living cells obtain energy, and how do they use it? This chapter will discuss different forms of energy and the physical laws that govern energy transfer.

5.1 The Cell Membrane

Learning objectives

By the end of this section, you will be able to:

- *Understand the fluid mosaic model of cell membranes*
- *Describe the functions of phospholipids, proteins, and carbohydrates when forming the cell membrane*
- *Be able to identify what types of molecules can pass directly through the membrane vs. those that need to use a transport protein to enter or exit the cell*
- *Be able to define and explain all bolded terms*

Despite differences in structure and function, all living cells are surrounded by a plasma membrane. As the outer layer of your skin separates your body from its environment, the cell membrane, also known as the plasma membrane, separates the inner contents of a cell from its exterior environment. This cell membrane provides a protective barrier around the cell and regulates which materials can pass into or out of the cell.

Fluid Mosaic Model

Scientists first identified the plasma membrane in the 1890s. In 1935, Hugh Davson and James Danielli proposed the plasma membrane's structure. This was the first model that was widely accepted by the scientific community. In the 1950s, advances in microscopy allowed researchers to see that the plasma membrane's core consisted of a double, rather than a single, layer of phospholipids, now referred to as the phospholipid bilayer. In 1972, S.J. Singer and Garth L. Nicolson proposed the fluid mosaic model which provided an explanation of the different observations and explained the function of the plasma membrane.

The **fluid mosaic model** has evolved somewhat over time, but it still best accounts for plasma membrane structure and function as we currently understand them. The fluid mosaic model describes the plasma membrane as a mosaic of components, including phospholipids, cholesterol, proteins, and carbohydrates (Figure 5.2). Fluid refers to the fact that materials making up the membrane move and are not rigid. Plasma membranes range from 5 to 10 nm in thickness. For comparison, human red blood cells, are approximately 8 µm wide, or approximately 1,000 times wider than a plasma membrane.

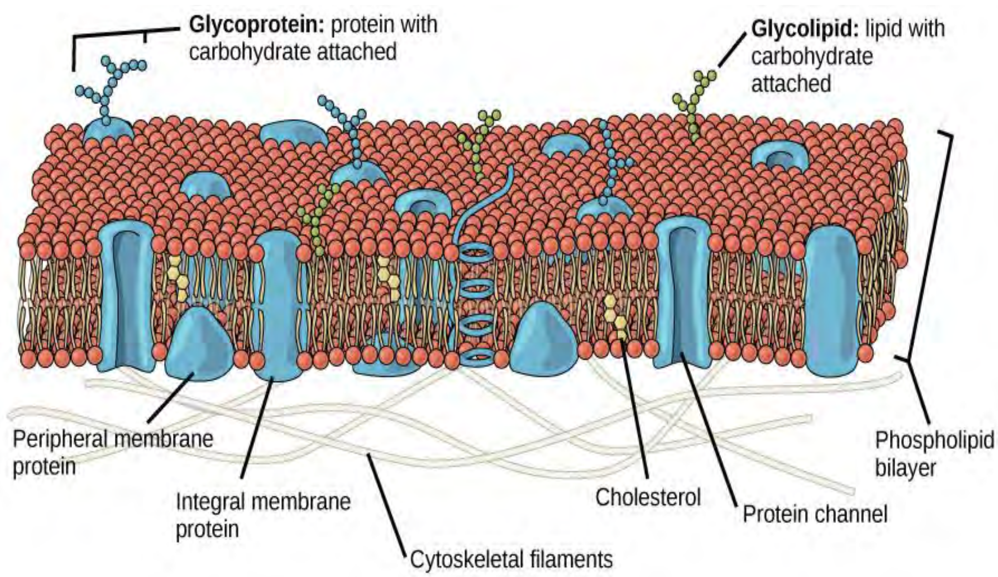

Figure 5.2 The plasma membrane fluid mosaic model describes the plasma membrane as a fluid combination of phospholipids, cholesterol, proteins, and carbohydrates. (credit: Betts et al./ Anatomy and Physiology OpenStax)

CONCEPTS IN ACTION - Visit this site to see animations of the membranes' fluidity and mosaic quality.

Structure and Composition of the Cell Membrane

The cell membrane is an extremely flexible structure. It is composed primarily of back-to-back phospholipids referred to as a phospholipid "bilayer" (Figure 5.3). Cholesterol is also present and contributes to the fluidity of the membrane. In addition, there are various proteins embedded within the membrane that have a variety of functions. We will now look separately at each component that makes up the plasma membrane.

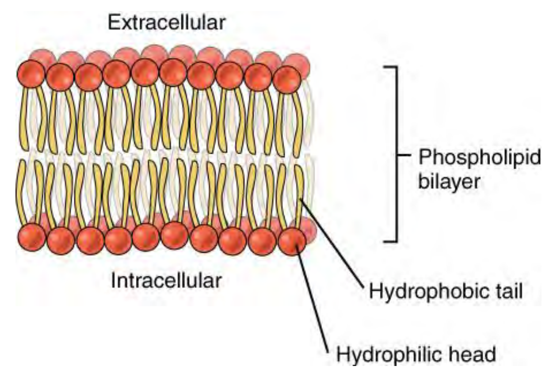

Figure 5.3 Phospholipid Bilayer (credit: Betts et al. / Anatomy and Physiology OpenStax)

Phospholipids

A single **phospholipid** molecule has a phosphate group on one end, called the "head," and two side-by-side fatty acid chains that make up the lipid "tails" (Figure 5.4). The phosphate group is negatively charged, making the head polar and hydrophilic, or "water-loving." The phosphate heads are attracted to water molecules found in both the extracellular and intracellular environments. The lipid tails are nonpolar and are hydrophobic. The hydrophobic lipid tails meet in the inner region of the membrane and exclude the watery intracellular and extracellular fluid. Most water that moves into or out of a cell does so through a transport protein called an **aquaporin**.

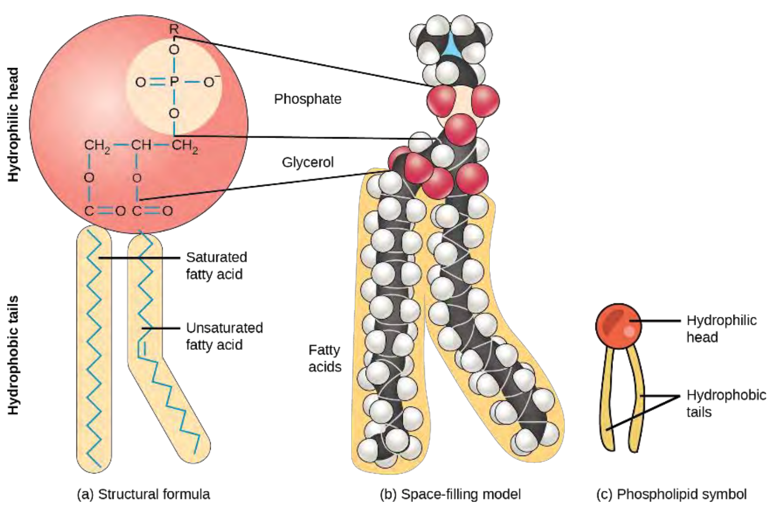

Figure 5.4 A hydrophilic head and two hydrophobic tails comprise this phospholipid molecule. (credit: Clark et al. / Biology 2E OpenStax)

Proteins

The lipid bilayer forms the basis of the cell membrane; however, there are various proteins peppered throughout. Membrane proteins are categorized as either integral proteins or peripheral proteins (Figure 5.2). As its name suggests, an **integral protein** is a protein that is embedded in the membrane. A transport protein is an example of an integral protein that selectively allows specific materials, such as ions, sugars, or molecules that are polar, to pass into or out of the cell. The aquaporin discussed above is also an example of an integral protein.