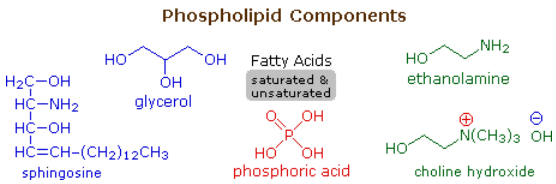
3.7: Application- The Cell Membrane

Phospholipids

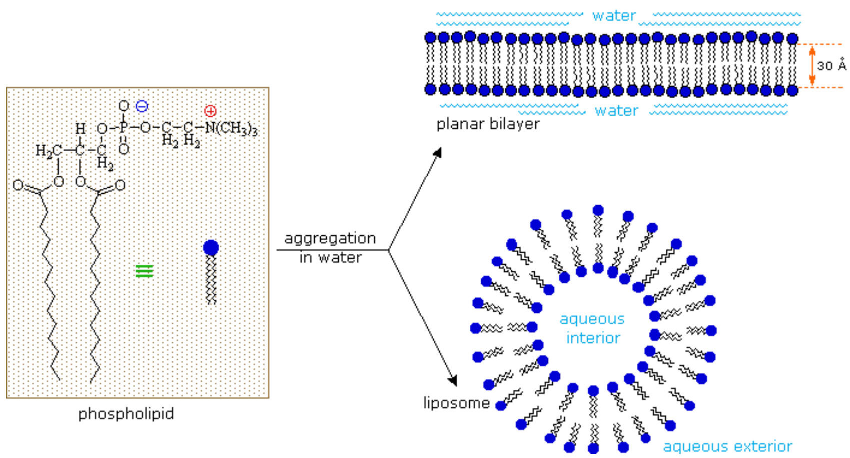
Phospholipids are the main constituents of cell membranes. They resemble the triglycerides in being ester or amide derivatives of glycerol or sphingosine with fatty acids and phosphoric acid. The phosphate moiety of the resulting phosphatidic acid is further esterified with ethanolamine, choline or serine in the phospholipid itself. The following diagram shows the structures of some of these components. Clicking on the diagram will change it to display structures for two representative phospholipids. Note that the fatty acid components (R & R') may be saturated or unsaturated.

To see a model of a phospholipid Click Here.



As ionic amphiphiles, phospholipids aggregate or self-assemble when mixed with water, but in a different manner than the soaps and detergents. Because of the two pendant alkyl chains present in phospholipids and the unusual mixed charges in their head groups, micelle formation is unfavorable relative to a bilayer structure. If a phospholipid is smeared over a small hole in a thin piece of plastic immersed in water, a stable planar bilayer of phospholipid molecules is created at the hole. As shown in the following diagram, the polar head groups on the faces of the bilayer contact water, and the hydrophobic alkyl chains form a nonpolar interior. The phospholipid molecules can move about in their half the bilayer, but there is a significant energy barrier preventing migration to the other side of the bilayer. **To see an enlarged segment of a phospholipid bilayer Click Here**.

This bilayer membrane structure is also found in aggregate structures called **liposomes**. Liposomes are microscopic vesicles consisting of an aqueous core enclosed in one or more phospholipid layers. They are formed when phospholipids are vigorously mixed with water. Unlike micelles, liposomes have both aqueous interiors and exteriors.



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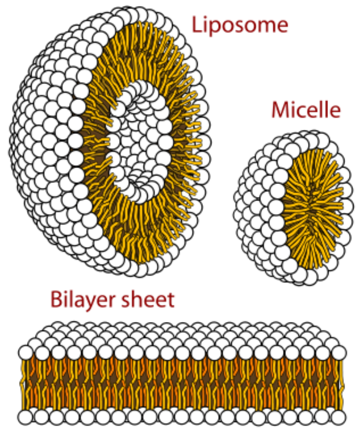

A cell may be considered a very complex liposome. The bilayer membrane that separates the interior of a cell from the surrounding fluids is largely composed of phospholipids, but it incorporates many other components, such as cholesterol, that contribute to its structural integrity. Protein channels that permit the transport of various kinds of chemical species in and out of the cell are also important components of cell membranes.

The interior of a cell contains a variety of structures (organelles) that conduct chemical operations vital to the cells existence. Molecules bonded to the surfaces of cells serve to identify specific cells and facilitate interaction with external chemical entities. The sphingomyelins are also membrane lipids. They are the major component of the myelin sheath surrounding nerve fibers. Multiple Sclerosis is a devastating disease in which the myelin sheath is lost, causing eventual paralysis.

Ionophores

Because the health of cells depends on maintaining the proper levels of cations in intracellular fluids, any change that affects the normal flux of metal ions across cell membranes could well cause an organism to die. Molecules that facilitate the transport of metal ions across membranes are generally called **ionophores** (ion plus phore from the Greek phorein, meaning “to carry”). Many ionophores are potent antibiotics that can kill or inhibit the growth of bacteria. An example is valinomycin, a cyclic molecule with a central cavity lined with oxygen atoms (part (a) in Figure 21.14 "Valinomycin Is an Antibiotic That Functions Like an Ionophore") that is similar to the cavity of a crown ether (part (a) in Figure 13.7 "Crown Ethers and Cryptands"). Like a crown ether, valinomycin is highly selective: its affinity for K^+ is about 1000 times greater than that for Na^+. By increasing the flux of K^+ ions into cells, valinomycin disrupts the normal K^+ gradient across a cell membrane, thereby killing the cell (part (b) in Figure 21.14 "Valinomycin Is an Antibiotic That Functions Like an Ionophore").

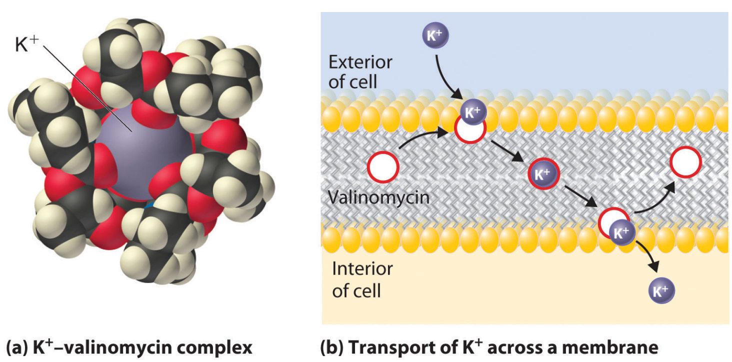

Figure 21.14 Valinomycin Is an Antibiotic That Functions Like an Ionophore

(a) This model of the structure of the K^+–valinomycin complex, determined by x-ray diffraction, shows how the valinomycin molecule wraps itself around the K^+ ion, shielding it from the environment, in a manner reminiscent of a crown ether complex. (For more information on the crown ethers, see Chapter 13 "Solutions", Section 13.2 "Solubility and Molecular Structure".) (b) Valinomycin kills bacteria by facilitating the transport of K^+ ions across the cell membrane, thereby disrupting the normal distribution of ions in the bacterium. At the surface of the membrane, valinomycin binds a K^+ ion. Because the hydrophobic exterior of the valinomycin molecule forms a “doughnut” that shields the positive charge of the metal ion, the K^+–valinomycin

complex is highly soluble in the nonpolar interior of the membrane. After the K^+–valinomycin complex diffuses across the membrane to the interior of the cell, the K^+ ion is released, and the valinomycin is free to diffuse back to the other side of the membrane to bind another K^+ ion. Valinomycin thereby destroys the normal K^+ gradient across the membrane, killing the cell.

Contributors

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