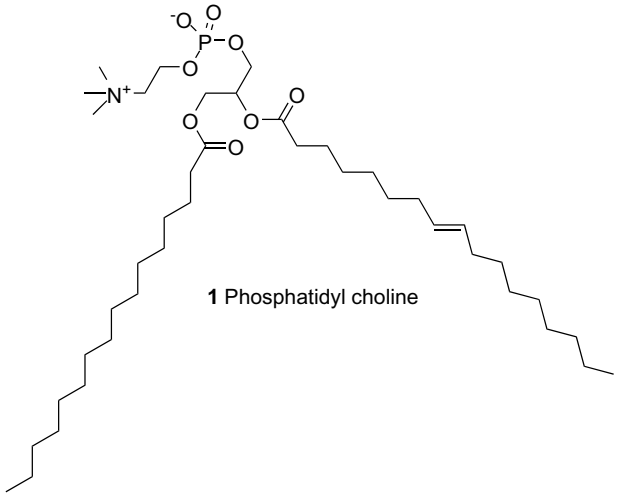
IMPACT 11 ON BIOCHEMISTRY

Biological membranes

Although lamellar micelles are convenient models of cell membranes, actual membranes are highly sophisticated structures. The basic structural element of a membrane is a phospholipid, such as phosphatidyl choline (**1**), which contains long hydrocarbon chains (typically in the range C_{14}–C_{24}) and a variety of polar groups, such as $—CH_2CH_2N(CH_3)_3^+$. The hydrophobic chains stack together to form an extensive bilayer about 5 nm across. The lipid molecules form layers instead of spherical micelles because the hydrocarbon chains are too bulky to allow packing into nearly spherical clusters.



1 Phosphatidyl choline

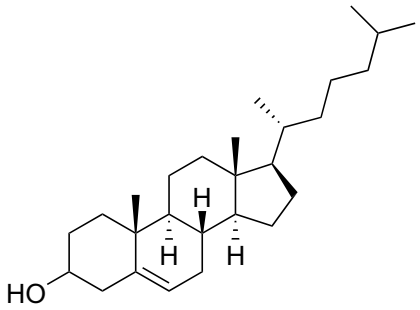
A bilayer is a highly mobile structure. Not only are the hydrocarbon chains ceaselessly twisting and turning in the region between the polar groups, but the phospholipid and other molecules inserted into the bilayer migrate over the surface. It is better to think of the membrane as a viscous fluid rather than a permanent structure, with a viscosity about 100 times that of water. In common with diffusional behaviour in general, the average distance a phospholipid molecule diffuses is proportional to the square-root of the time. Typically, a phospholipid molecule migrates through about 1 μm (the diameter of a cell) in about 1 min.

Peripheral proteins are proteins attached to the bilayer. **Integral proteins** are proteins immersed in the mobile but viscous bilayer. These proteins may span the depth of the bilayer and consist of tightly packed α-helices or, in some cases, β-sheets containing hydrophobic residues that sit comfortably within the hydrocarbon region of the bilayer. There are two views of the motion of integral proteins in the bilayer. In the **fluid mosaic model**, the proteins are mobile, but their diffusion coefficients are much smaller than those of the lipids. In the **lipid raft model**, a number of lipid and cholesterol molecules form ordered structures, or 'rafts', that envelope proteins and help carry them to specific parts of the cell.

The mobility of the bilayer enables it to flow round a molecule close to the outer surface, to engulf it, and incorporate it into the cell by the process of **endocytosis**. Alternatively, material from the cell interior wrapped in cell membrane may coalesce with the cell membrane itself, which then withdraws and ejects the material in the process of **exocytosis**. The function of the proteins embedded in the bilayer, though, is to act as devices for transporting matter into and out of the cell in a more subtle manner. By providing hydrophilic channels through an otherwise alien hydrophobic environment, some proteins act as ion channels and ion pumps.

All lipid bilayers undergo a transition from a state of high to low chain mobility at a temperature that depends on the structure of the lipid. There is sufficient energy available at normal temperatures for limited bond rotation to occur and the flexible chains writhe about. However, the membrane still has a great deal of order in the sense that the bilayer structure does not come apart and the system is best described as a liquid crystal. At lower temperatures, the amplitudes of the writhing motion decrease until a specific temperature is reached at which motion is largely frozen. The membrane is then said to exist as a gel. Biological membranes exist as liquid crystals at physiological temperatures.

Interspersed among the phospholipids of biological membranes are sterols such as cholesterol (**2**), which is largely hydrophobic but does contain a hydrophilic —OH group. Sterols, which are present in different proportions in different types of cells, prevent the hydrophobic chains of lipids from 'freezing' into a gel and, by disrupting the packing of the chains, spread the melting point of the membrane over a range of temperatures.



2 Cholesterol