All living things that show anisotropy (i.e. their physical properties are not the same in all directions) either are, or once were, in a liquid crystal state. There are many examples of liquid crystals in biology and a few are described here. All biological liquid crystals involve lyotropic phases, i.e. they are formed by aggregates of molecules in a solvent (water).

Perhaps the most important example of a biological liquid crystal is the cell membrane. The layered (lamellar) structure can be seen in the diagram opposite.

The lamellar structure of the cell membrane in photoreceptors is important in polarized light vision in fish. There, the liquid crystal order also orients the molecule that absorbs light.

One of the most striking examples of liquid crystals in biology is in the iridescent colours displayed by some beetles (see sheet on CHOLESTERIC LIQUID CRYSTALS AND BEETLES). These are produced in some scarab beetles by the secretion of a cholesteric liquid crystal state in the late chrysalis phase. The resulting coat is iridescent and reflects circularly polarized light.

Other common biological materials that form lyotropic liquid crystals include bile acid salts, long chain fatty acids, stereo esters, retinols and vitamins A, E and K. In some cases these materials require the presence of a third component for the formation of liquid crystal phases as they are not very soluble in water.

Myelin, which forms the sheath around nerve cells and is prominent in the transmission of electrical impulses by the nerve, is also liquid crystalline, and indeed was one of the first liquid crystals observed (though at the time, it was not recognised as one). Studies show that most of the cholesterol that occurs in myelin and in the brain, is synthesised in situ and forms a lamellar phase with water.

Other examples of biological lyotropic liquid crystals include DNA and viruses. Blood can, in some circumstances, form a liquid crystal phase, a situation which is rather dangerous because it causes the viscosity to increase, hindering the flow. The condition where this occurs is known as sickle cell anaemia.

It is not surprising that so many biological systems exhibit liquid crystal phases. Biological systems generally need to be a fluids – solids don’t easily respond to change (they break!), and isotropic liquids (without order) have less capacity to include functionality. The combination of fluidity and order, which is what defines the liquid crystal state, is an obvious pre-requisite for many biological structures!