

# **How Lipid Chemical Structure Determines Physical Structure: A Practical Approach.**

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All lipids contain major fractions of non-polar hydrocarbon moieties in their molecular structures. Frequently these occur as linear chains with lengths of 12-18 carbons which have a tendency to form solids. Most lipids also contain polar groups, ranging from weakly dipolar esters moieties, through the alcohols (H-bonding), to zwitterionic and ionic groups. The polar groups interact with water, and this tends to promote liquid-like physical states. The presence of the hydrocarbon groups causes lipids to aggregate in aqueous mixtures, frequently leading to the occurrence of structures with long range order (liquid crystals/mesophases). Depending on the exact chemical structure of the lipid, the liquid crystals can vary in their molecular motion, from being very close to a liquid state to having an almost crystalline rigidity. In the literature there is a very large body of data on the phases of pure lipids that provides a firm basis for elucidating the behaviour of any new system.

Pure lipids have their equilibrium behaviour constrained by the Gibbs phase rule. However, with mesophases, the formation of metastable states having long lifetimes is fairly common. Moreover, the higher the degree of molecular mobility within a phase, the more different compounds can mix together. Thus natural lipids, with their distribution of hydrocarbon structures, occur as mesophases when pure lipids do not.

This lecture will review the various phases formed by lipids, demonstrating how chemical structure determines phase properties. The phases include “gels” (rotator phases) and the common liquid crystals (lamellar, cubic, hexagonal, etc.). The most appropriate techniques to determine particular phase structures will also be described (microscopy, NMR, X-rays, dsc, ...). Their use will be illustrated using some recent results. For lecithins we have observed a large structural relaxation within the “gel” phase which disappears in the presence of a membrane protein. Some conventional surfactants have coexisting patches similar to those occurring in membranes, allowing the underlying molecular mechanism to be determined.