3 Object of Interest: Lipid Bilayers

3.1 Cell Membrane and Lipids

Biological cells are surrounded the cell membrane as shown in figure ??. The main building block are lipids, amphiphilic molecules with polar head groups and a hydrophobic fatty acid chains. Besides lipids cell membranes are composed by many other elements such as proteins. The cell membrane can not be assumed as a solid skin, since its elements exhibit a great variety of dynamics. Therefore, it rather has to be described as a complex two-dimensional fluid, in which elements are free to move and diffuse as in other liquids. This model is called fluidic mosaic membrane model [3].

3.2 Lipids and Lipid Analogs

The main building block of membranes are lipids. Lipids in general are amphiphilic molecules with fatty acid hydrocarbon chain and a hydrophilic headgroup. Lipids can be classified in four different groups:

- Phospholipids
- Sphingolipids
- Glycolipids
- Steroles

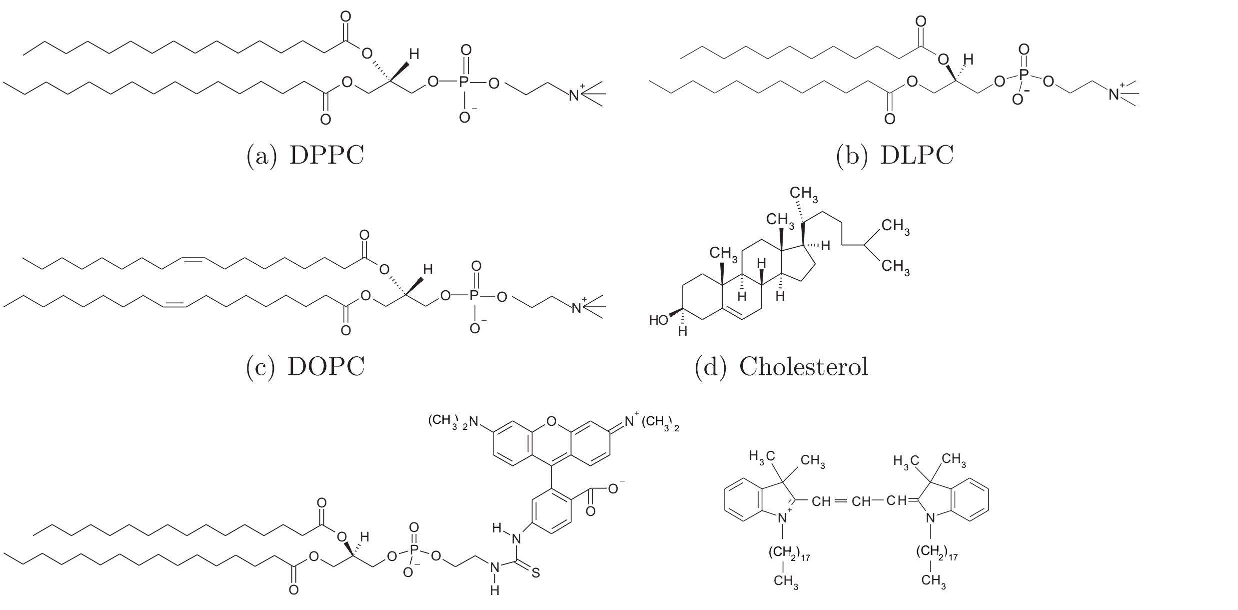
Besides structure elements of membranes lipids serve as energy resources (sphingolipids), enzyme cofactors, light absorbers, intracellular messenger etc. In this work we are interested in lipids as structure elements of membranes which are mostly phospholipids. Another important building block is cholesterol which was used in this work to since its incorporation into lipid membranes is supposed to influence the membrane fluidity.

Fluorescent probes were inserted into membranes built by the given phospholipids. These fluorescent probes are either lipids to which fluorophores are linked such as TRITC-DHPE or fluorophores which have a similar amphiphilic structure to lipids such as DiI-C18. Function of those fluorescent probes will be discussed later.

In figure 3.1 chemical structures of lipids and lipid analogs used in this work are shown, chemical and physical properties are given in table 3.1.

Acronym	Chemical Name	Totals formula	Molecular weight in mg/mol
DPPC	1,2-Dipalmitoyl-sn-Glycero-3-Phosphocholine	$C_{40}H_{80}NO_8P$	734.05
DOPC	1,2-Dipalmitoyl-sn-Glycero-3-Phosphocholine	$C_{40}H_{80}NO_8P$	734.05
DLPC	1,2-Dilauroyl-sn-Glycero-3-Phosphocholine	$C_{32}H_{64}NO_8P$	621.84
Cholesterol	Cholesterol	$C_{27}H_{46}O$	386.66
TRITC-DHPE	N-(6- tetramethylrhodaminethiocarbamoyl)-1,2-dihexadecanoyl-sn-glycero-3-phosphoethanolamine	$C_{68}H_{110}N_5O_{11}PS$	1236.68
DiIC18	1,1'-dioctadecyl-3,3,3',3'-tetramethylindocarbocyanine perchlorate	$C_{59}H_{97}ClN_2O_4$	933.88

Table 3.1:

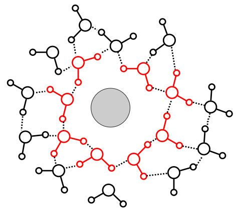


(a) DPPC (b) DLPC

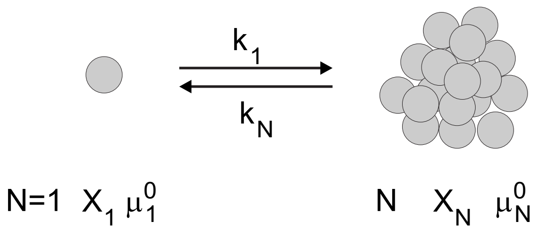
(c) DOPC (d) Cholesterol

(e) TRITC-DHPE (f) DiI-C18

Figure 3.1: Lipids and lipid analogs used in this work.



(a) H_2O-molecules (red) in next neighborhood to the hydrophobic molecule (grey) have less possibilities to establish H-bonds. This situation is therefore entropically unfavored.



(b) Monomers and aggregates of hydrophobic molecules are in equilibrium exchange

Figure 3.2:

3.3 Constitution of Lipid Structures

Content of this section is mainly taken from *Intermolecular & Surface Forces* by Jacob Israelachvili [4].

Aggregation of lipids is a self-assembled process stimulated by lipid interactions such as van der Waals, hydrophobic, electrostatic interactions and H-bonds.

In general, the presence of an individual hydrophobic molecule in an aqueous environment is entropically highly unfavored. H_2O-molecules are forced to build H-bonds around the hydrophobic molecule forming so called clathrate-structures which represent high order of H_2O-molecules and therefore low entropy [5], a sketch is given in figure 3.2(a). Therefore hydrophobic molecules in an aqueous environment tend to aggregate in order to decrease the presence of clathrate-structures. This aggregation is a thermodynamic equilibrium process with a constant chemical potential

$$\mu = \underbrace{\mu_1^0 + k_B T \ln X_1}_{\text{Monomer}} = \underbrace{\mu_2^0 + k_B T \ln X_2}_{\text{Dimer}} = \ldots = \underbrace{\mu_N^0 + k_B T \ln X_N}_{\text{Aggregate of } N \text{ molecules}} = \mu_N = const. \tag{3.1}$$

where μ_N is the mean chemical potential of a molecule in an aggregate of aggregation number N, μ_N^0 the mean interaction free energy per molecule in aggregates of aggregation number N, and X_N the concentration of molecules in aggregates of number N ([4]). Aggregates are in equilibrium with individual molecules determined by reaction rates k:

$$\frac{k_1}{k_N} = e^{-N \frac{\mu_N^0 - \mu_1^0}{k_B T}} \tag{3.2}$$

This is also true for amphiphilic molecules such as lipids. I would like to give a short insight into the self-assembly process of lipids.