Polar Lipids

1. Polar lipids form bilayers spontaneously in water.
2. A purified polar lipid from membranes, e.g., phosphatidyl choline (PC), contain up to 30 combinations of fatty acids on its chains.
3. Bilayers of a pure (synthetic) lipid have four states, liquid, liquid crystal, gel and crystal.
4. Such bilayers display a sharp \( T_m \), which is defined at the gel to liquid crystal transition.
5. The \( T_m \) is very low for polyunsaturated chains and very high for saturated chains.
6. Biological membranes are always just above the \( T_m \), in the liquid crystal state.
7. Examples are fish and alcoholics.
8. There are three classes of polar lipids, zwitterionic, uncharged (glyco-) and anionic. There are no cationic lipids in nature.

ZWITTERIONIC LIPIDS (PC, PE= phosphatidyl ethanolamine, SM= sphingomyelin)
Conformation (x-ray structures of crystals agree with NMR conformations)
   A. Phosphate is above the glycerol
   B. Glycerol is perpendicular to the membrane.
   C. Primary ester is below the glycerol.
   D. Secondary ester is parallel to the membrane before (at C2) the chain plunges.
   E. The base (choline or ethanolamine) spins at an angle (~15°) to the plane.
   F. Each headgroup interacts with three neighbors ionically (+,-)

UNCHARGED LIPIDS (glycolipids, cerebrosides, gangliosides)
   A. Glycolipids have H-bonds with neighbors.
   B. Each lipid has three neighbors.
   C. Gangliosides & S-lipids have H-bond lateral interactions but the surface is anionic.

ANIONIC LIPIDS (PG, P-glycerol; PI, P-inositol; CL; cardiolipin, PS, P-serine, many others)
   A. Conformation same as the zwitterionic lipids.
   B. Repulsive interactions alleviated by screening of cations from solution + H-bonds.
   C. pH at the surface below that of water (2-3 units if not in salt).
   D. pH difference disappears at high ionic strength.
   E. Surface can bind Ca^{++} and H^+, which facilitate fusion.
   F. Always involved in fusion.

ACID-ANION FORMATION PROVOKES H+ TO ACT AS AN ATTRACTANT.
   A. Cardiolipin as an acid-anion.
   B. Fusion occurs because of acid-anion formation. Negative charges become attractive by trapping protons.
   C. All membranes have a net negative charge on their surface. This attracts cations to the surface. Cations are pumped in all bioenergetic membranes. (H^+ & Na^+).
   D. All biological membranes have a proton gradient maintained by a proton pump (except the animal plasma membrane, which has a sodium gradient).