Hydrophobicity [pln19]

 H_2O molecules are *polar*, meaning that each hydrogen is electropositive and the oxygen is electronegative. Liquid water is a polar medium. It forms a dynamic network of hydrogen bonds between adjacent H_2O molecules.

Different kinds of polar molecules may participate in this dynamic network as both donor or acceptor ends of hydrogen bonds. They are called *hydrophilic*. *Non-polar* molecules are electroneutral. They do not participate in the formation of hydrogen bonds and are called *hydrophobic*. Surfactant molecules consist of hydrophilic parts and hydrophobic parts (e.g. polar headgroups and non-polar tails of lipids) and are called *amphiphilic*.

When molecules in low concentration (*solute*) are added to liquid water (*solvent*) they behave such as to minimize the free energy. The change in Gibbs free energy,

$$\Delta G = \Delta H - T\Delta S,$$

has enthalpic and entropic contributions. A favorable enthalpic contribution, $\Delta H < 0$, results when repulsive interactions are avoided and/or attractive interactions facilitated. A favorable entropic contribution, $\Delta S > 0$, results when disorder (number of available microstates) increases overall.

Hydrophilic solute molecules lower the enthalpy by participating in the formation of hydrogen bonds with water and increase the entropy by spreading across the volume in solution.

Hydrophobic solute molecules and H_2O solvent molecules form interfaces with unsatisfied hydrogen bonds. Agglomeration of solute molecules lowers the interface area and thus lowers the enthalpy but it also lowers the entropy. The minimum free energy is a compromise, characterized by low solubility and significant agglomerations.

Amphiphilic solute molecules tend to self-assemble into structures (micelles, liposomes, bilayers, ...) that shield their hydrophobic parts from exposure to water while their hydrophilic parts participate in the dynamic network of hydrogen bonds of the solvent. This arrangement lowers the enthalpy considerably albeit at some cost in entropy.

Divertissement: Switzerland shares three of its four official languages (German, French, Italian) and a great deal of cultural affinity with powerful, sometimes overbearing neighbors. Its survival as a nation through the centuries (since 1291) is attributable, at least in part, to a hydrophobic effect in the realms of politics and ideology.