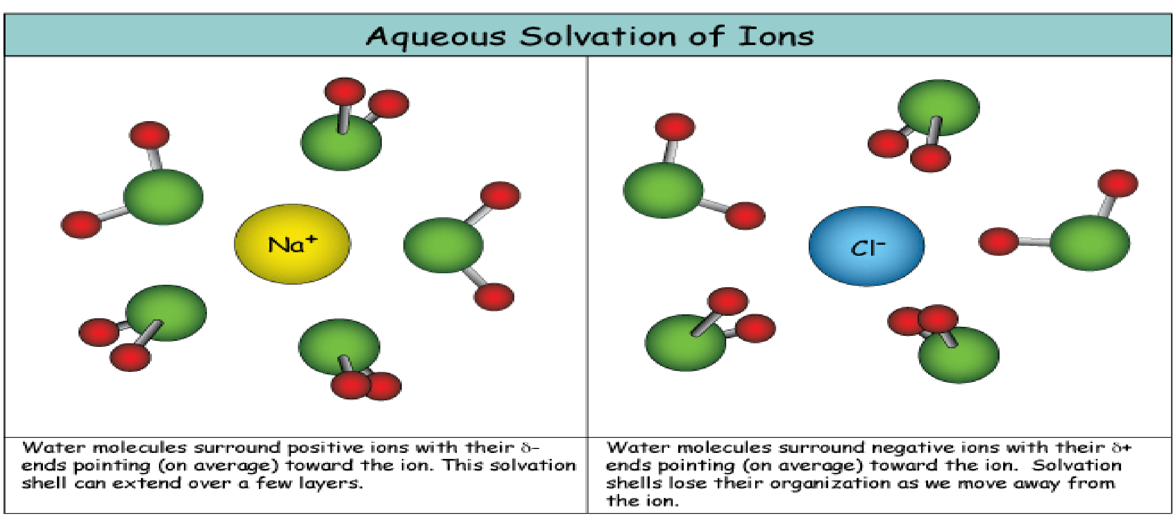
THE HYDROPHOBIC EFFECT

A very important consequence of the fact that water is polar might be summed up by the phrase "like dissolves like." That mnemonic means that polar or charged substances (like CH_3OH or HCl) tend to dissolve in polar solvents (like water or ethanol), while nonpolar substances (like methane and benzene) tend to dissolve in nonpolar solvents (like carbon tetrachloride, CCl_4).

Here are a couple of pictures (below) of the first **solvation shell** that tends to form around **ions** in solution. Charged species are like water in that they bear a charge imbalance (in the case of ions, they *are* a charge imbalance). The positive "ends" (the hydrogens) of water molecules tend to orient toward a negative ion, and the lone-pair electron density tends to orient toward a positive ion. Remember that liquid water is a dynamic substance, with each water molecule in a constant tumbling motion. Still, at any one time a picture more or like this is likely to exist:



Water molecules surround positive ions with their δ- ends pointing (on average) toward the ion. This solvation shell can extend over a few layers.

Water molecules surround negative ions with their δ+ ends pointing (on average) toward the ion. Solvation shells lose their organization as we move away from the ion.

Micelles, Vesicles, and Membranes

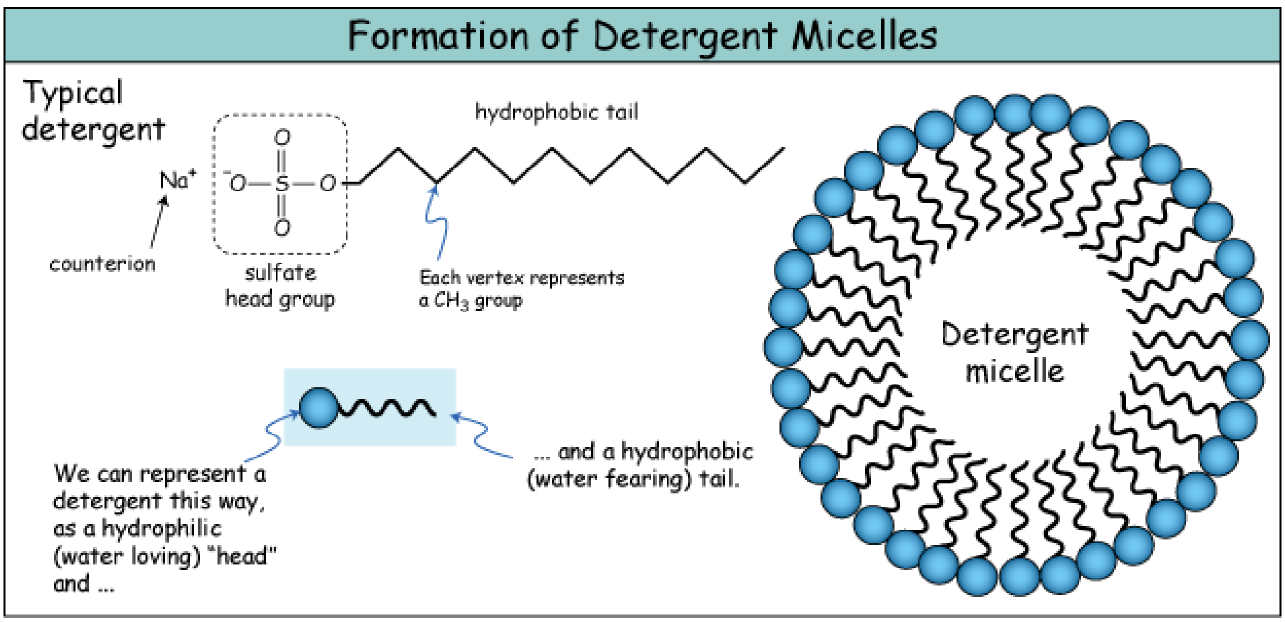
When we attempt to dissolve very nonpolar solutes in water, they often just don't dissolve. For example, nonpolar oils and waxes, which are mostly composed of long chains of -CH_3- units, tend to separate from water when we try to mix them. Generally oil is of lower density than water and when left undisturbed, floats on top of the water.

Oils, waxes and other nonpolar substances are called **hydrophobic**, which means "water fearing". Hydrophobic substances dissolve in other hydrophobic solvents like CCl_4, hexane or benzene. But when a hydrophobic substance is placed in water it tends to associate with the most hydrophobic thing present, usually *itself*. Thus oil aggregates into droplets, then drops, and finally into a layer completely separate from water, minimizing the unfavorable interaction between hydrophobic molecules and water.

It is instructive to think about **detergents**. As shown in the diagram below, detergents consist of a charged or polar "**head group**", usually a sulfate or a phosphate, attached to a long hydrophobic **tail**, usually just composed of repeating CH_3 units: -CH_2-CH_2-CH_2-CH_2-CH_2-CH_2- ... The detergent shown below is one of the most common, sodium dodecyl sulfate, a sulfate head group with 12 CH_2 groups in the tail.

Detergents tend to form **micelles** in water. Micelles are little globs of detergent molecules with the polar heads forming the interface with water molecules, and the hydrophobic tails buried inside the spherical micelle. Everything's happy: The head groups are surrounded by polar water molecules, and water is excluded from the core of the micelle, where hydrophobic tails solvate one another.

Formation of micelles like this is driven by the hydrophobic effect.

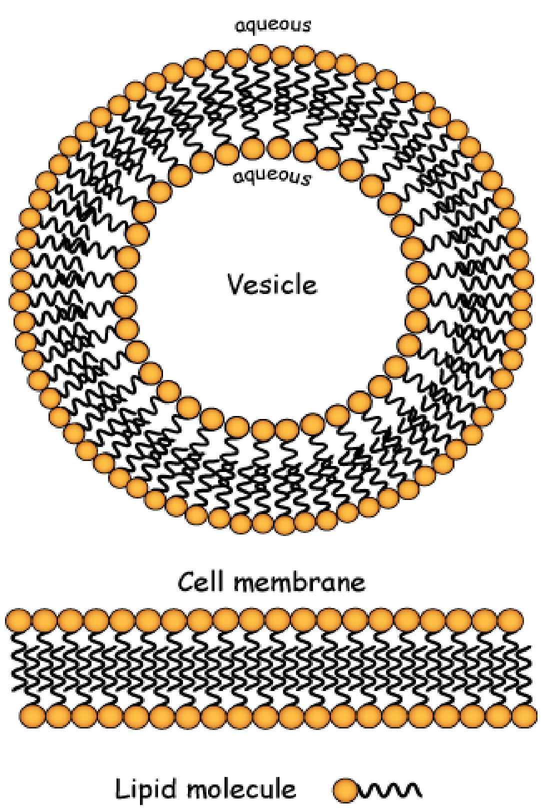


Lipid molecules (**fats**) are similar to detergents in that they consist of a charged or polar head and a hydrophobic tail. These molecules tend to form membranes - like cell **membranes** – and **vesicles**, small, spherical closed membrane sacs that are used by cells to transport molecules.

Look at the pictures of the vesicle and membrane section on the right. Notice that the head groups are on the outside where they can be solvated by water molecules and the hydrophobic tails are inside of a region that excludes water.

Again, the hydrophobic effect drives the formation of these structures. They form spontaneously when lipids are placed in aqueous solution.

Note: These membrane drawings are highly idealized. Real cell membranes can contain a variety of different lipid types, and usually membranes are pierced by many kinds of proteins that exist to help transport something into or out of the cell, or to signal something that are going on inside the cell to the "world" outside.



Source: http://www.drcruzan.com/Water.html