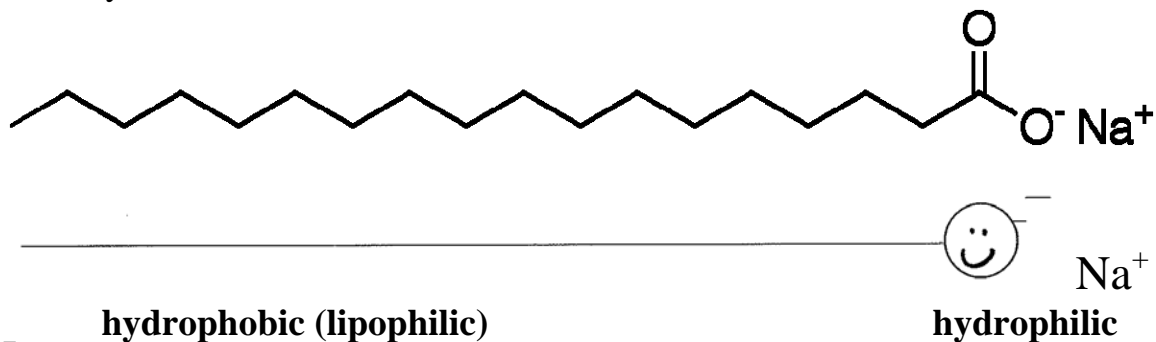


4.10 Micelles and Soaps

The solubility of carboxylic acids is similar to that of alcohols and amines. The carboxylic acid is slightly more effective than an OH group in pulling a non-polar chain into water, but we will not worry about small differences and will stick to our 4:1 rule of thumb: one carboxylic acid functional group can solubilize a nonpolar chain of about 4 C atoms. If we neutralize the carboxylic acid and convert it into a carboxylate ion, the ionic **carboxylate ion is much more effective** at pulling a non-polar chain into aqueous solution. The carboxylate ions can pull fairly long non-polar chains (up to about 18 C atoms) into solution. The carboxylate ions dissolve in solution by forming special structures called **micelles**. Micelles account for the cleaning action of soap and other similar molecules.

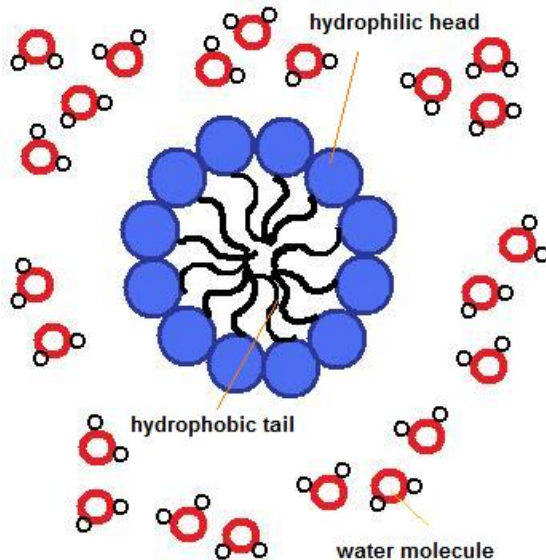
To discuss micelles, we will introduce a shorthand notation for the carboxylate ions, shown below:



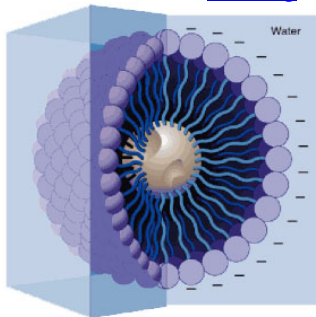
The portion that wants to dissolve in water is referred to as **hydrophilic** and is represented by a circle. The portion that does not want to dissolve in water is called **hydrophobic or lipophilic** and is represented by a line: the string on the balloon, so to speak. The negatively charged (anionic) carboxylate ion must have a positive ion (a cation) to balance its charge. When a K^+ is the ion, the result is soft soap; when Na^+ is the positive ion hard bar soap results. When Li^+ is the positive ion we end up with a hard soap with a very high melting point; this compound is not used for human cleaning action, but is added to some greases to provide cleaning action in axles!

A group of carboxylate ions form a micelle by forming a sphere with their **hydrophilic** portions in contact with the outside of the sphere and they hide their hydrophobic (**lipophilic**) portions inside the sphere. When one

dissolves soap in water, the soap molecules form micelles and in fact the properties of micelles account for how soap works to dissolve grease.



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Grease and fats are non-polar molecules and they won't dissolve in pure water. You can scrub that greasy plate in water all day long and all you'll get is a thin even distribution of grease on your plates. However, when you have soap dissolved in water micelles with nonpolar (hydrophobic) interiors are formed that can dissolve nonpolar compounds quite well. The grease molecules on the plate dissolve inside the soap micelles. Micelles cannot absorb an infinite amount of grease. As more non-polar molecules are added to the interior, the size of the micelle increases, but the number of hydrophilic groups on the surface does not. Eventually, the hydrophilic groups cannot solubilize the enlarging hydrophobic interior and a separate oil phase may start appearing in your dish water. Then its time for some new dish water!

When the soap micelles dissolve fat into their hydrophobic (nonpolar) interiors, we say that the soap is **emulsifying** the oil or fat globules. The

soap is pulling non-polar molecules into an aqueous solution where it would not normally be soluble. A solution containing micelles is referred to as an **emulsion**. Molecules that can form micelles are also referred to as **emulsifying agents, wetting agents, or surfactants** (a shortened word for surface active agent). If the surfactant molecule has a negative charge, it is referred to as an **anionic surfactant**; if the surfactant has a positive charge, it is called a **cationic surfactant**.

Soaps are by no means the only molecules that can form micelles. There are in fact a huge number of surfactants that have great importance in medical and everyday life. We'll look further into some of these important molecules.