Bridging the gap….molecules that like oil AND water

Model 1. Molecules that love water are called *hydrophilic* – these molecules dissolve well in water. Molecules that hate water (love oil/fat) are called *hydrophobic* – these molecules separate from (will not dissolve in) water. Molecules with both hydrophilic and hydrophobic parts are called *amphiphilic*. *Amphiphilic molecules* can make oil/fat and water mix together by bridging the gap…

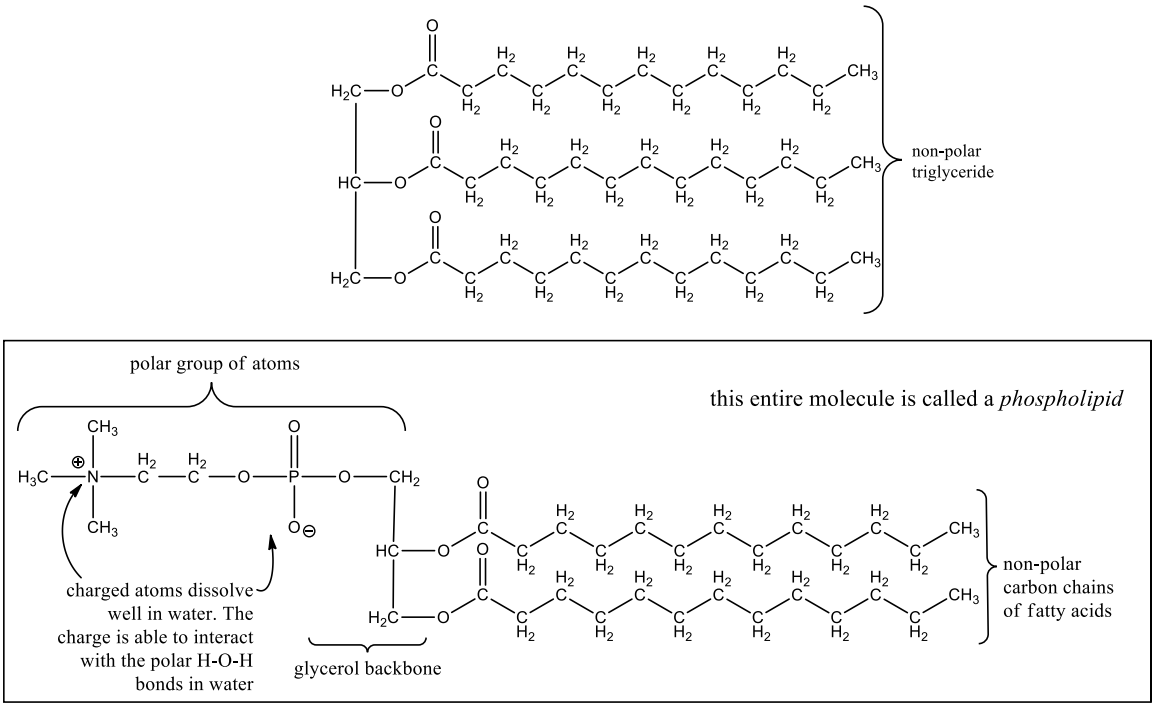


Figure 12.1. A phospholipid is a molecule with both non-polar and polar parts

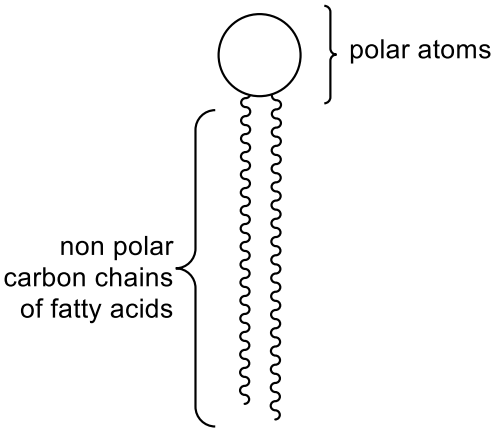


Figure 12.2. A cartoon drawing of a phospholipid

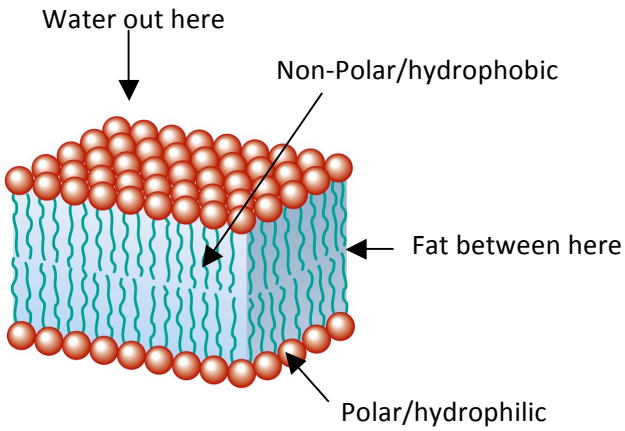


Figure 12.3. Phospholipids mediate interactions between fat molecules dissolved in water[1]

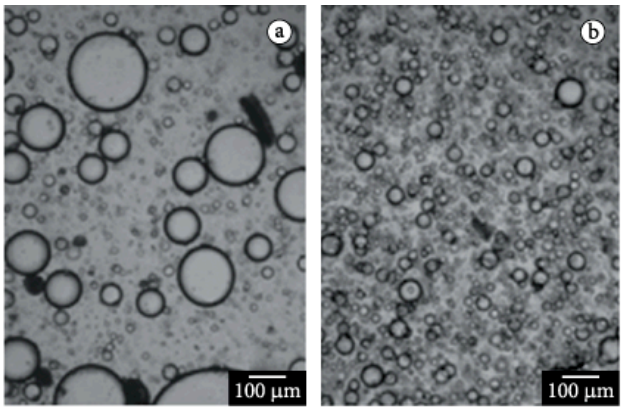


Figure 12.4. Different salad dressing emulsions under the microscope. The circular droplets of fat are dispersed in the water phase. The smaller the fat droplets, the more stable the *emulsion*.[2]

Amphiphilic molecules are great *emulsifiers* – they can mix with water AND fat and bring the two phases together in a fine, cream-like, stable mixture. When fats/oils and water form a stable mixture (i.e. one that is not separated into two phases) it is called an *emulsion*. Many food products are emulsions: mayonnaise, hollandaise, some salad dressings, milk, cream, clam chowder etc. Amphiphilic molecules hold the emulsion (the mixture of water and fat/oil) together by "half" dissolving in the water and "half" dissolving in the fat.

[1] Phospholipid bilayer image is from Boyer's Concepts in Biochemistry Figure 8.9
[2] Ciênc. Tecnol. Aliment., Campinas, 30(2): 477-482, abr.-jun. 2010

Lecithin is phospholipid and natural emulsifier that is abundant in egg yolks – it comprises >30% of the egg yolk lipids. *Lecithin* can also be found in soy.

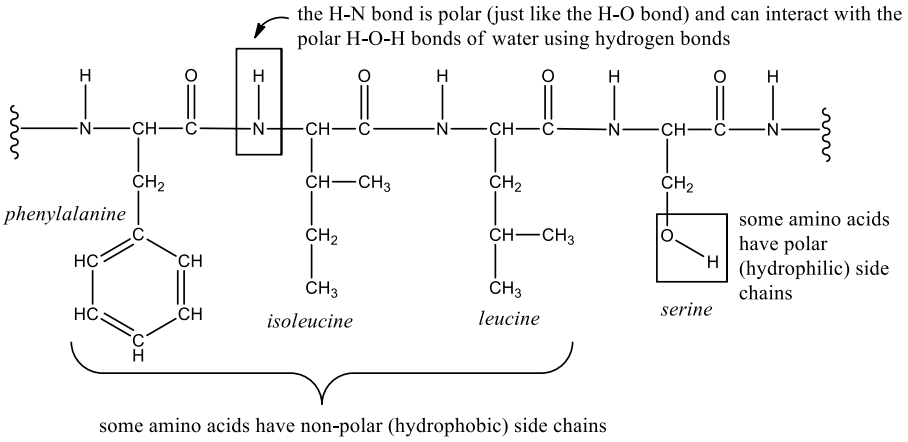
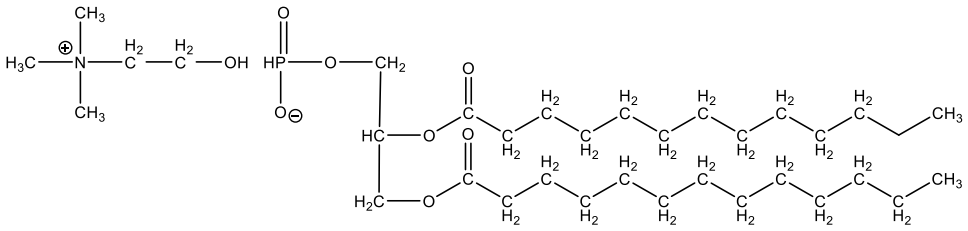


Figure 12.5. Proteins can also act as emulsifiers. Some amino acids have polar side chains, and the H-N bonds of the amino acids are polar, while other amino acids have non-polar side chains (contain only H-C bonds). The combination of polar and non-polar within one molecule makes proteins *amphiphilic*.

Milk is an emulsion of water and fat ("cream") stabilized by milk proteins as the emulsifiers. Fresh milk from the cow that has not yet been mechanically *homogenized* into an emulsion will separate into the two phases: water and "cream". *Homogenization* creates a stable emulsion of tiny fat droplets in water - and the milk proteins mediate the interactions between these tiny fat droplets and the water. The proteins coat the fat droplets and keep them from joining together into a large fat phase. *Homogenization* of milk into a stable emulsion gives it a creamy mouth-feel.

1. Explain why a phospholipid is also a diglyceride.

2. Using a drawing, show how the polar (hydrophilic) group of the phospholipid is able to interact with the polar H-O-H bonds in water. Remember that the O-H bonds in water are polar (Activity 4).



3. When you look at an emulsion under a microscope you see fat droplets dispersed in a watery liquid. What properties of the molecules create this separation or boundary between the phases?

4. Draw a cartoon that shows how a phospholipid “bridges the gap” between water and fat.

5. Looking at Figure 12.4, which image has the more stable emulsion. Why?

6. Why is the side chain of isoleucine non-polar (hydrophobic)?

7. Why is the side chain of serine polar (hydrophilic)?

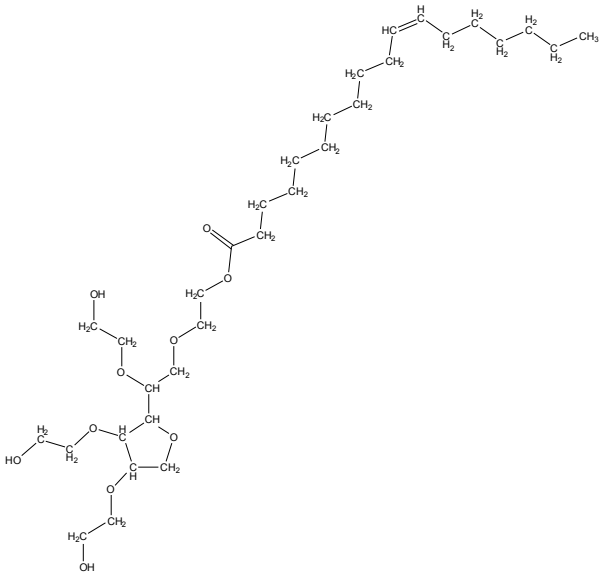
8. Gelatin is also an emulsifier. Gelatin is a mixture of protein made from animal muscle. What gives gelatin its emulsifying properties?

Putting it all Together:

9. Mayonnaise is an emulsion made of three main ingredients: oil, vinegar and egg yolks (lemon juice and mustard are sometimes added as well). Explain how the 3 main ingredients work together to make the stable emulsion.

10. Mustard is sometimes also used as an emulsifier. Considering mustard seed is about ~30% protein, ~30% carbohydrate, and ~30% oil, what is responsible for the emulsifying properties of mustard?

11. Ice cream contains a number of different *emulsifiers*. Added whey protein (a type of milk protein) or gelatin protein are used to coat the milk fat. Custards use the lecithin of egg yolks as an emulsifier. Polysorbate 80 is an emulsifier that keeps ice cream scoopable. The structure of polysorbate 80 is shown below:



a. Why is this molecule a good emulsifier? Remember, the molecule must have polar (hydrophilic) and non-polar (hydrophobic) parts.

b. *Circle* the part of the molecule interacts with water and soluble protein, and *draw a box* around the part of the molecule that interacts with the fat globules.