A note from Dr. Haas: Lipids are molecules that are mostly nonpolar, but have some polar character. These molecules serve important biological functions, such as providing the principle component of membranes (phospholipid bilayers) and serving as energy storage (fat). The structures of a triglyceride and a phospholipid are shown above. Triglycerides are the things we commonly refer to as “fats” and “oils”. Phospholipids are similar to triglycerides with one important difference.

A skeletal structure of a phospholipid and a triglyceride are shown above. Notice the similarities and differences between the two structures. The phospholipid is similar to the triglyceride in that it contains fatty acid tails attached to a glycerol backbone. However, the phospholipid contains an organic phosphate zwitterion instead of a third fatty acid tail.

Triglycerides are completely insoluble in water. However, due to the ionic organic phosphate group, phospholipids demonstrate properties because the ionic group is attracted to water. Phospholipids have both a polar, hydrophilic end, and a nonpolar, hydrophobic end. Phospholipids are partially soluble in water, meaning that part of the molecule is attracted to water, and part of it is not. Phospholipids form important structures in water when the polar end faces water and the nonpolar end faces away from water. Below is a cartoon version of the phospholipid bilayer in 2D.

Phospholipid bilayers separate aqueous compartments in cells. They act as semipermeable membranes that allow only very small or nonpolar molecules through. Membranes also contain small molecules (ex cholesterol, coenzymeQ) and proteins, which can be embedded in the bilayer or can span from one side of the membrane to the other.

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Lipid Bilayer Membrane

Every cell is enclosed by a membrane which gives structure to the cell and allows for the passage of nutrients and wastes into and out of the cell. The purpose of the bilayer membrane is to separate the cell contents from the outside environment. The outside of the cell is mostly water and the inside of the cell is mostly water. The cell membrane may be coated with other molecules such as carbohydrates and proteins, which serve as receptor sites for other messenger molecules. Interaction with the cell membrane allows for molecular communication signals to pass from outside to inside of the cell.

Introduction

Cell membranes are composed of two classes of molecules: lipids and proteins. The proteins serve as enzymes, carry molecules, and provide the membrane with distinctive functional properties. Details of proteins and enzyme structures are given elsewhere. The lipids provide the structural integrity for the cell. The lipids found in the membrane consist of two parts: hydrophilic (water soluble) and hydrophobic (water insoluble). The hydrophobic portion of the lipids is the non-polar long hydrocarbon chains of two fatty acids. The fatty acids are present as esters bonded to glycerol. The third-OH group on glycerol is ester bonded to phosphate hence the term phospholipid. The phosphate ester portion of the molecule is
polar or even ionic and hence is water soluble. A simple interaction of several phospholipids is shown in the graphic on the left.

There are two common phospholipids found in the bilayer:

1. **Lecithin** contains the amino alcohol, choline.
2. **Cephalins** contain the amino alcohols serine or ethanolamine.

The arrangement of phospholipids in cell membranes has been deduced by X-Ray diffraction data. The phospholipids are arranged as a bilayer (two molecules thick). The phospholipids are stacked with the non-polar hydrocarbon chains pointed inward while the polar ends act as the external surface as shown in graphic on the left. The structure of the bilayer is another application of the solubility principle of “likes dissolve likes”.

Most of the fatty acids in the membrane are unsaturated because this allows the membrane to be more flexible (cis bonds are bent) to allow certain molecules through the membrane. However, the interaction of the hydrophobic inside of the layer acts as a barrier for ionic and polar molecules from entering the inside of the cell. In animal cells **cholesterol** is inserted between the non-polar chains, and makes up about 20% of the molecules of the membrane. This helps to make the membrane more rigid and adds strength.

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**Lipid Bilayer Graphic:** Red/white spheres represent water molecules on the outside surfaces of the bilayer which are hydrophilic (water loving). The gray spheres represent the non-polar hydrocarbon chains, which are hydrophobic or water hating. The purple spheres represent individual phospholipid molecules.

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**References**

- Chime from: Dr. William McClure, Department of Biological Sciences, Carnegie Mellon University, Pittsburgh, PA 15213

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