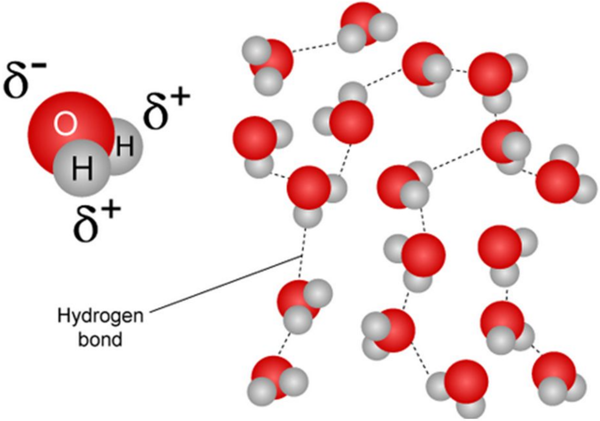
Biological containers: phospholipid membranes

To understand the formation of membranes, we first need to review **hydrogen bonding** in water:



Bond length: 0.3 - 0.4 nm **Strength:** $0.04 - 0.2$ eV = $1.6 - 9\ k_B T$

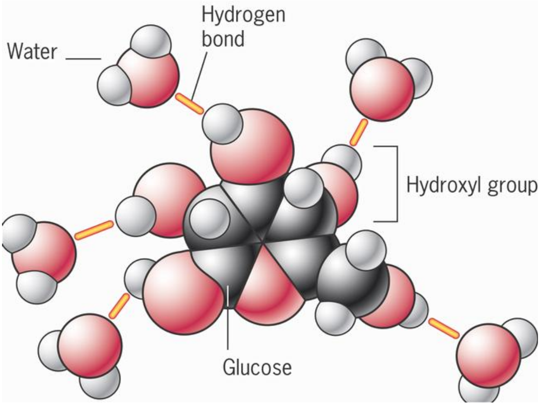
Dynamic hydrogen bond network in water

See movie on course website.

Hydrophiles

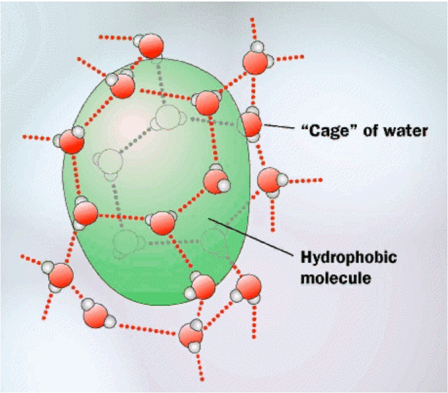
Hydrogen bond partners do not have to be water, but have a general structure: $X - H \cdots Y$ where X and Y are electronegative.

Hydrophilic molecules have charged or polar groups on surface which readily form H bonds with water.



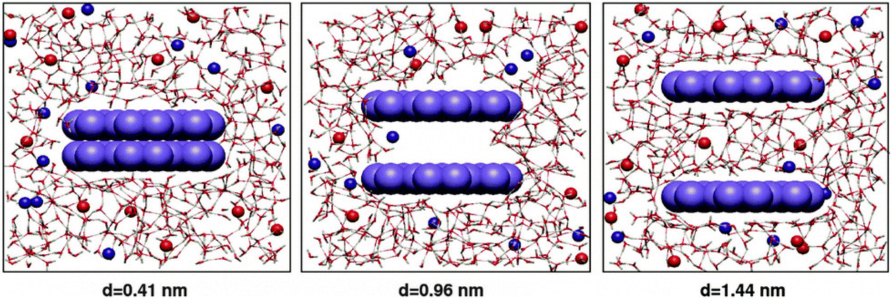
Hydrophobes

The opposite are **hydrophobes**, which disrupt the hydrogen bond network of water, forming an energetically costly “cage”.



Hydrophobic effect

Minimizing this disruption drives hydrophobic objects to strongly aggregate together in water.



Zangi *et al.*, J. Am. Chem. Soc. (2007)

Effective strength of attraction between 2 nm hydrophobic plates:
$140 - 200$ kJ/mol $\approx 60 - 80\ k_B T$

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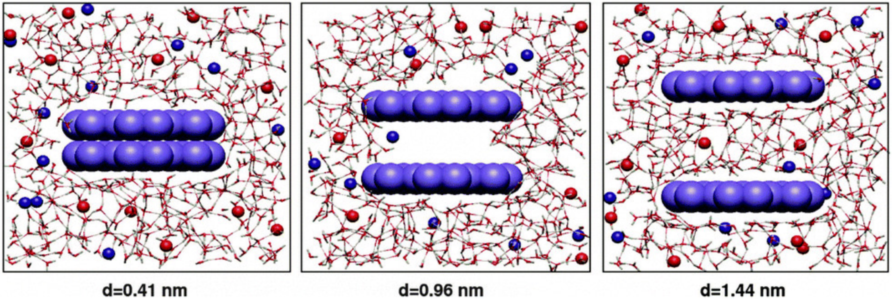

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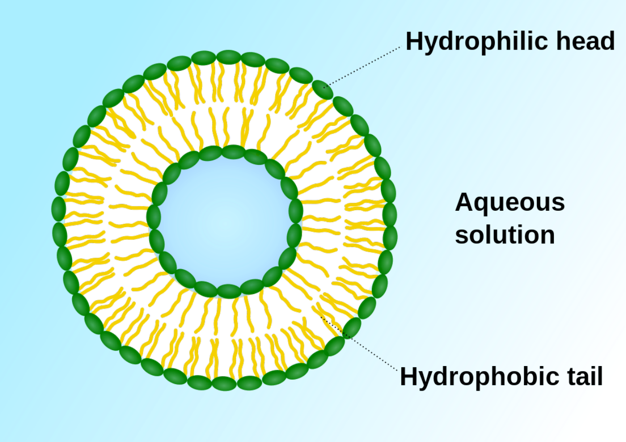
This hydrophobic effect is a crucial factor driving the folding of proteins and the assembly of membranes.

Phospholipid structures

Phospholipids have hydrophilic (negatively charged phosphate) heads and hydrophobic (fatty acid) tails. The aggregation of the latter leads to a variety of possible **self-assembled** structures.



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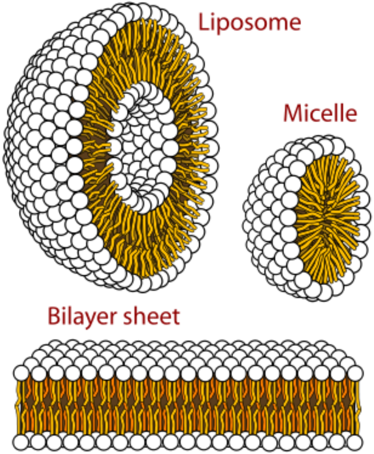


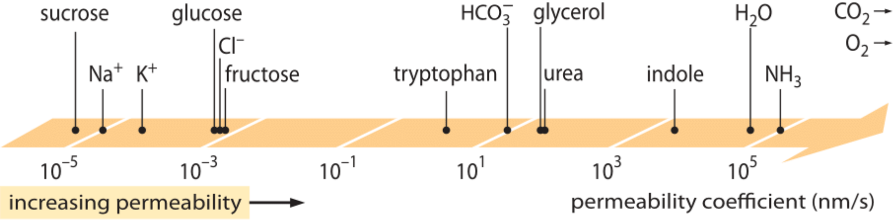
Permeability of phosolipid membranes

Smaller, typically uncharged molecules (like water) can squeeze through:

See movie on course website.

Permeability scales

The degree of permeability for different biological molecules varies over ten orders of magnitude:



Source: book.bionumbers.org