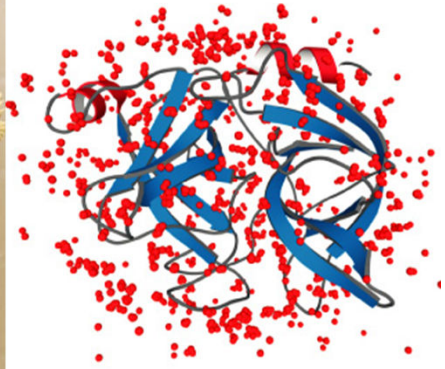
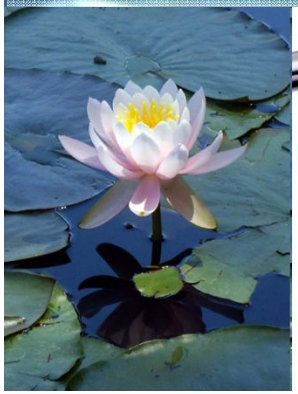


Water

The solvent of life





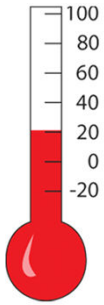
- **Why is water essential for life?**
- **How does water influence life (at the molecular level)?**

Which environment is best suited to the development of life?

Too unstable

Too limited

Liquid water is essential for life because it provides stability and richness



Stability of temperature

How?

Why?

High heat capacity

Large heat of fusion

Large heat of vaporization

H-bonding!

Stability of state (liquid)

Large liquid range

Floating ice insulates water below; large bodies stay liquid

Richness of dissolved cpds and chemistry

Good solvent

Protic, amphoteric

Many of water's unique properties are due to the extent of its hydrogen bonding

Water contains only H-bonding groups

- Compare with methanol, ethanol

Water has 2 H-bond donors and 2 acceptors

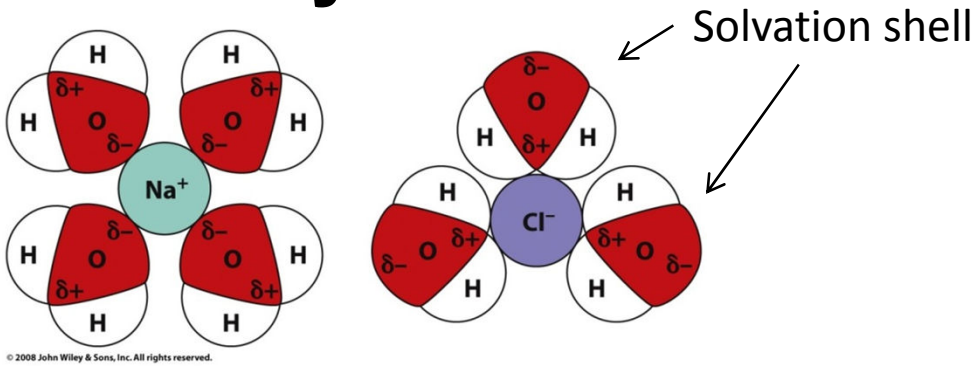
- Compare with ammonia

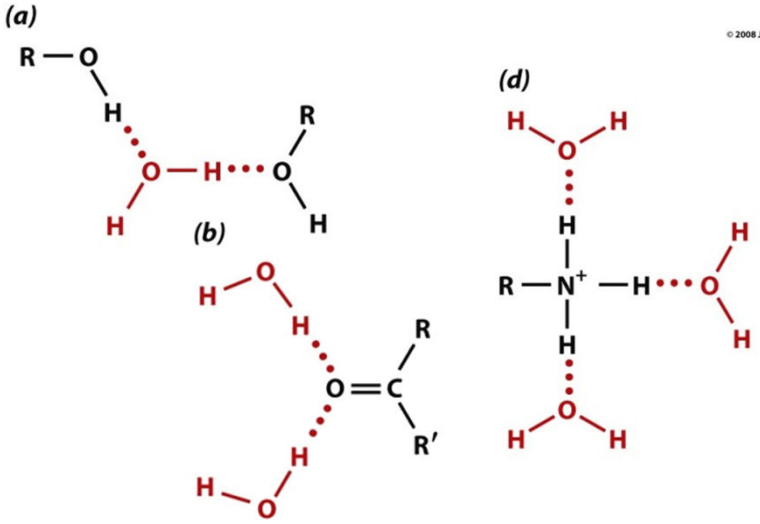
- **Why is water essential for life?**
- **How does water influence life (at the molecular level)?**

Water interacts with biomolecules, influencing their chemistry

Water dissolves polar and ionic compounds

Adds richness, hinders access



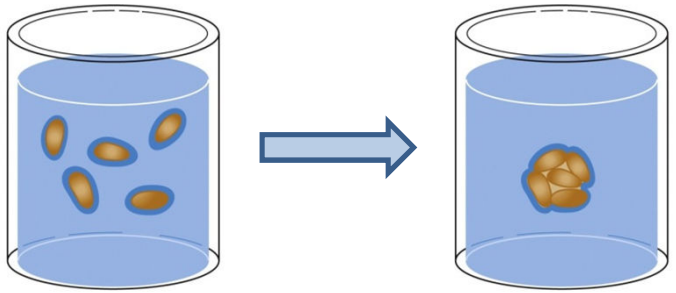


Water forms electrostatic or H-bonding interactions with polar & ionic groups

May stabilize structure, link interactors

Water pushes nonpolar compounds together

Creates 'order'



The hydrophobic effect is driven by changes in entropy

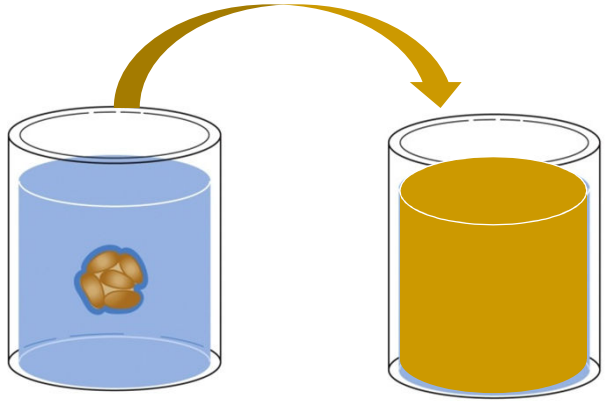


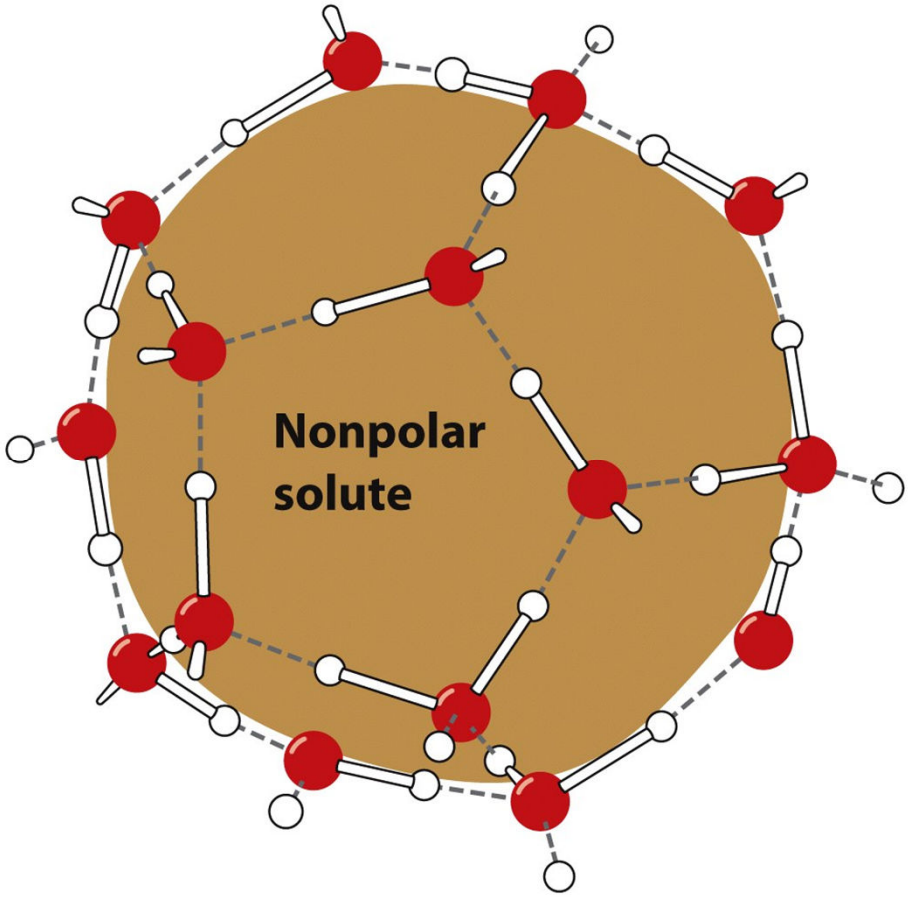
Table 2-2 Thermodynamic Changes for Transferring Hydrocarbons from Water to Nonpolar Solvents at 25°C

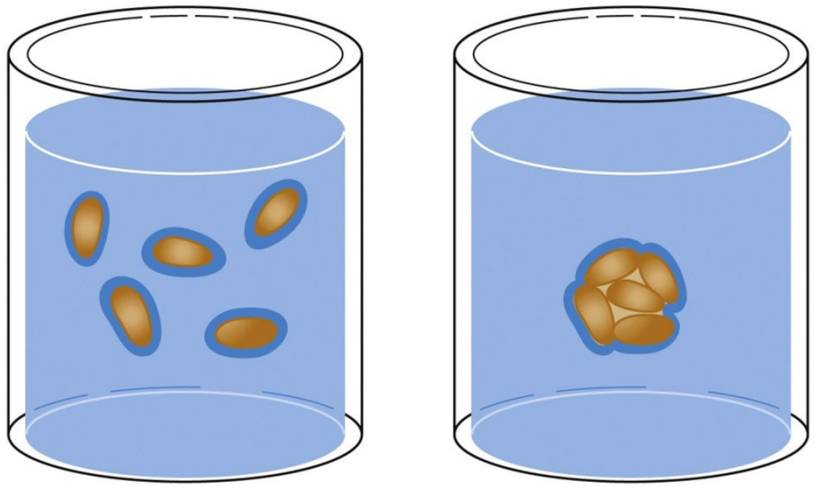
Process	ΔH (kJ · mol^{-1})	$-T\Delta S$ (kJ · mol^{-1})	ΔG (kJ · mol^{-1})
CH_4 in $H_2O \rightleftharpoons CH_4$ in C_6H_6	11.7	−22.6	−10.9
CH_4 in $H_2O \rightleftharpoons CH_4$ in CCl_4	10.5	−22.6	−12.1
C_2H_6 in $H_2O \rightleftharpoons C_2H_6$ in benzene	9.2	−25.1	−15.9
C_2H_4 in $H_2O \rightleftharpoons C_2H_4$ in benzene	6.7	−18.8	−12.1
C_2H_2 in $H_2O \rightleftharpoons C_2H_2$ in benzene	0.8	−8.8	−8.0
Benzene in $H_2O \rightleftharpoons$ liquid benzene[a]	0.0	−17.2	−17.2
Toluene in $H_2O \rightleftharpoons$ liquid toluene[a]	0.0	−20.0	−20.0

[a]Data measured at 18°C.

Source: Kauzmann, W., *Adv. Protein Chem.* **14,** 39 (1959).

Water entropy is the major contributor to the hydrophobic effect





Reduction in nonpolar surface area
= reduction in ordered water

Figure 2-8

Water also participates in biochemical reactions

- ATP hydrolysis drives muscle contraction
  - $ATP + H_2O \rightarrow ADP + HPO_4^{2-}$

- Proteins and polysaccharides are hydrolyzed into component amino acids or sugars

- Water adds to alkenes to form alcohols
  - Ex: fumarase reaction of citric acid cycle

$^{-}OOC\text{-}CH{=}CH\text{-}COO^{-} + H_2O \rightarrow {}^{-}OOC\text{-}CHOH\text{-}CH_2\text{-}COO^{-}$