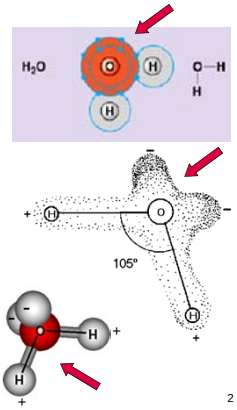
## Water

- O-H bonds are polar
- Bond angles place the H atoms on one side of the molecule
- Therefore, the water molecule is polar

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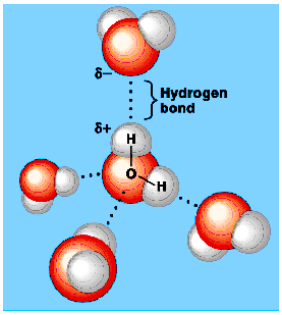
## Hydrogen bonds among water molecules




This tetrahedral arrangement is the pattern in which water coheres in an ice crystal…in liquid water the arrangement is more random

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## Hydrogen bonds

- hydrogen in polar covalent bonds is attracted to nearby electronegative atoms (O or N)
- weak electrostatic bonds – easily broken
- Very important in biology. Examples:
  - properties of water
  - protein folding
  - DNA and RNA folding

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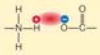
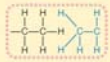
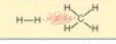
**TABLE 2.1**

**Chemical Bonds and Interactions**

| NAME | BASIS OF INTERACTION | STRUCTURE | BOND ENERGY* (KCAL/MOL) |
|---|---|---|---|
| Covalent bond | Sharing of electron pairs |  | 50–110 |
| Ionic bond | Attraction of opposite changes |  | 3–7 |
| Hydrogen bond | Sharing of H atom |  | 3–7 |
| Hydrophobic interaction | Interaction of nonpolar substances in the presence of polar substances (especially water) |  | 1–2 |
| van der Waals interaction | Interaction of electrons of nonpolar substances |  | 1 |

*Bond energy is the amount of energy needed to separate two bonded or interacting atoms under physiological conditions.

Regarding this table from Sadava, note how strong covalent bonds are compared to other forces holding molecules together.

*LIFE 8e*, Table 2.1

## Properties of water

- Cohesion
- Surface tension
- Adhesion to hydrophilic substances e.g. cellulose
- Not to hydrophobic substances e.g. waxes

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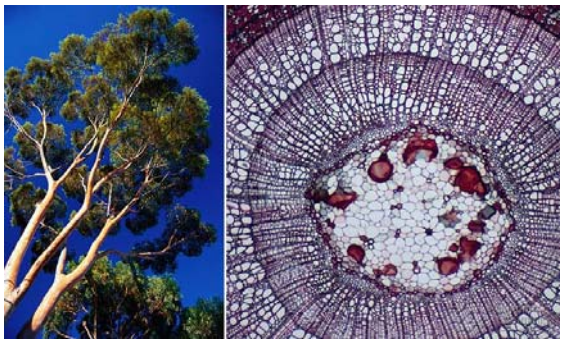
Figure 3.2 Water transport in plants



Cross-section of a woody stem, showing xylem vessels

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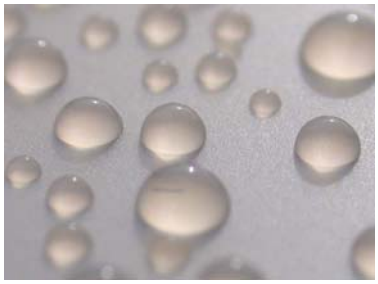
## Surface tension shapes water on a hydrophobic surface



The drops would be spherical, if it weren't for gravity…why?

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## Walking on water


## Water physical phases

Ice crystal structure Liquid water Water vapor

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## Heat

- random movements of atoms and molecules
- add heat: faster movement, higher temperature (heat energy per molecule)
- no heat = "absolute zero" (-273° Celsius, 0° Kelvin)
- units of heat: calorie, kcal = Calorie, calorie=4.184 Joules

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## Water stabilizes temperature

- Specific heat: 1 cal/g °C
- Heat of fusion: ~80 cal/g released by freezing, absorbed by melting
- Heat of vaporization: ~539 cal/g absorbed by evaporation, released by condensation.
- Water expands as it freezes: ice less dense and floats

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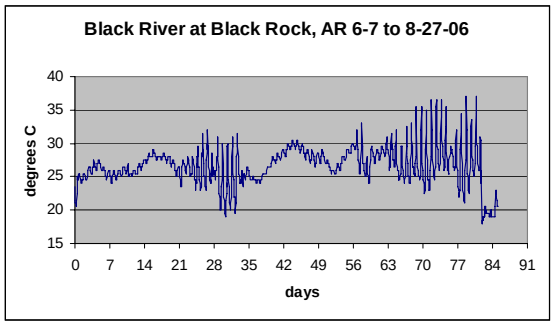


One of my temperature recorders, placed in (very) shallow water in the Black River - can you explain the fluctuations?

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Floating ice and the fitness of the environment

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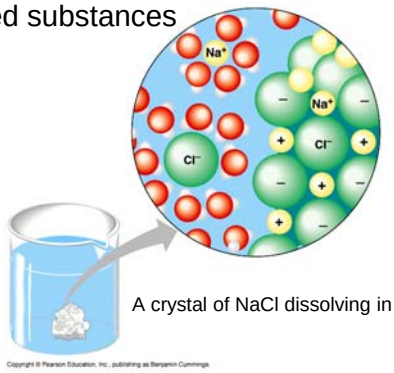
Water is good solvent for polar or ionized substances




A crystal of NaCl dissolving in water



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## Electrolytes

- Compounds held together by ionic bonds that dissolve in polar solvents
- example: sodium chloride (NaCl) becomes $Na^+$ and $Cl^-$
- electrolytes are the most abundant solutes in body fluids- common ions include $Na^+$ $Cl^-$ $K^+$ $HCO_3^-$

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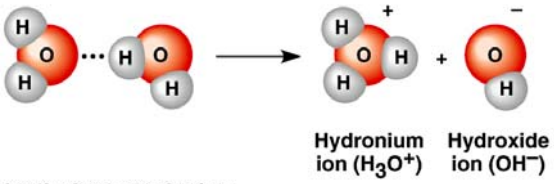
## Water is a weak electrolyte






$H_3O^+$ or just $H^+$

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## Acid-base relations

- In pure water at 20 ºC:
  - $[H_2O]$ = 55.4 M
  - one molecule in 554 million is dissociated
  - $[H^+] = 10^{-7}$ M
  - pH = -log $[H^+]$ = 7
- pH is the negative logarithm (base 10) of the hydrogen ion concentration

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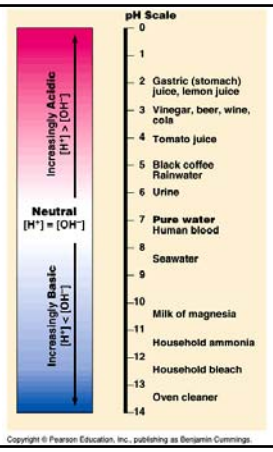


pH of aqueous solutions

"acidic"
higher $[H^+]$, lower pH

"basic"
lower $[H^+]$, higher pH

neutral

buffer
stabilizes pH

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- End of water slides

- …on to the next set: Organic Chemistry

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