

3.1.7 Water

SPECIFICATION

Water is a major component of cells. It has several properties that are important in biology. In particular, water:

- is a metabolite in many metabolic reactions, including condensation and hydrolysis reactions
- is an important solvent in which metabolic reactions occur has a relatively high heat capacity, buffering changes in temperature
- has a relatively large latent heat of vaporisation, providing a cooling effect with little loss of water through evaporation
- has strong cohesion between water molecules; this supports columns of water in the tube-like transport cells of plants and produces surface tension where water meets air.

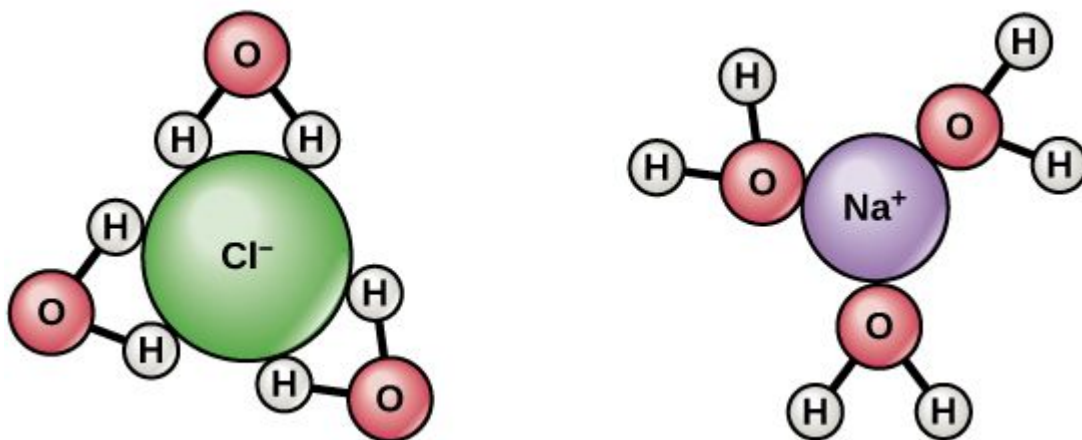
Water

Water is an important constituent of the tissues. Typically about 60% of the water we take in comes from drinks, 30% from food and the remaining 10% is metabolic water (a byproduct of respiration).

Water As a Solvent

- Water molecules are charged, with the oxygen atom being slightly negative and the hydrogen atoms being slightly positive.
- These opposite charges attract to each other, forming hydrogen bonds that bind water molecules loosely together
- Because it is charged, water is a very good solvent, and almost all the chemical reactions of life take place in aqueous solution.
- Charged or polar molecules such as salts, sugars, amino acids dissolve readily in water and so are called hydrophilic ("water loving").
- Uncharged or nonpolar molecules such as lipids do not dissolve so well in water and are called hydrophobic ("water hating").

Hydrogen bonds are formed between an atom (usually hydrogen) with a slight positive charge (denoted d^+) and an atom (usually oxygen or nitrogen) with a slight negative charge (denoted d^-). Because hydrogen bonds are weak they can break and form spontaneously at the temperatures found in living cells without needing enzymes.



When table salt (NaCl) is mixed in water, spheres of hydration are formed around the ions.

Water Can Resist Changes in Temperature

- Hydrogen bonds between water molecules can absorb a lot of energy
- This means that water has a high specific heat capacity - it takes a lot of energy to heat it up.
- Water has a specific heat capacity of $4.2 \text{ J g}^{-1} \text{ }^{\circ}\text{C}^{-1}$, which means that it takes 4.2 joules of energy to heat 1 g of water by 1°C .
- This unusually high heat capacity means that water does not change temperature very easily.
- The constant temperature is useful for living organisms because it means water doesn't experience rapid temperature changes.
- Water is a good habitat as the temperature underwater is likely to be more stable to on land.
- Water inside organisms is also fairly stable - which helps them to maintain a constant internal body temperature.

Strong cohesion between water molecules

- Cohesion is the tendency of molecules within a substance to “stick together”
- Water molecules are very cohesive because they are polar hydrogen bonds
- A strong cohesion helps water to flow, which is useful for transporting substances - for example the xylem (tube-like transport cells) in plants relies on water being pulled up
- Cohesion also gives the water a high surface tension, allowing small organisms like pond skaters and other insects to “walk” on the surface of a pond

Density and freezing properties

- Water is unusual because its solid form is less dense than its liquid form. Below 4°C the density of water starts to decrease.
- Ice floats on water and insulates the water below it - reducing the chances of large bodies of water completely freezing and increasing the chances of life.
- Changes in density of water with temperature set up ocean currents, which circulate nutrients.

Photosynthesis

- Water is used in photosynthesis, so it is responsible for the production of glucose. This in turn is used in the synthesis of many chemicals.