Biological Importance of Water

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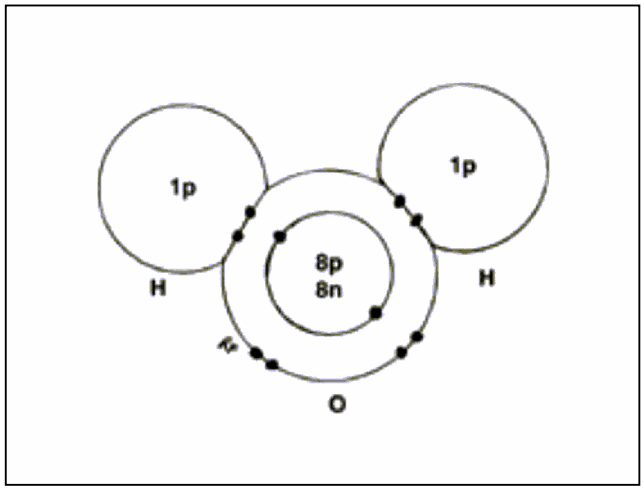
Water is an important part of life: Without it, life on earth would not exist. Water is a major component in cells, typically forming 70 to 95% of the cell's mass. In humans water is around 80% of our mass. Water also provides an environment for organisms to live in. One obvious example of water's biological importance is that 75% of the Earth is covered in water.

Water is one of the most unusual compounds on Earth. It has a variety of properties not found in any other liquid. These properties are due to its **molecular composition**, which is simply just 2 hydrogen atoms and one oxygen atom, making up H20.

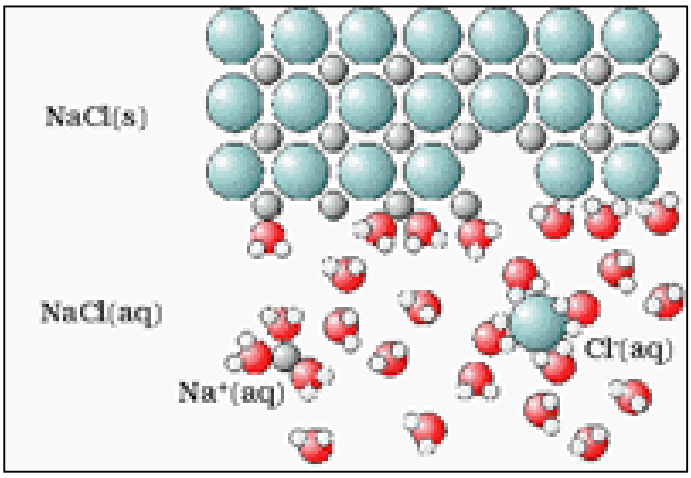


Water is a covalent compound. This means that water has **covalent bonds**, which are formed by **sharing electrons** in the outer orbits of the quantum shells. In the case of water however the large number of protons in the oxygen nucleus have a stronger attraction for these shared electrons than the comparatively tiny hydrogen nuclei. This pulls the electrons slightly closer to the oxygen nucleus and away from the hydrogen so that the oxygen develops a slight negative charge and the hydrogen's a slight positive charge. This makes the water molecule a slightly **Polar Molecule.**

This slight charge gives water its various properties; the first I will discuss is its solvent properties.

Water can act as a solvent. "Things" can dissolve in solvents and therefore "things" can dissolve in water. Substances that dissolve in water sre known as hydrophilic substances Water can dissolve polar or ionic substances, because they contain a charge.

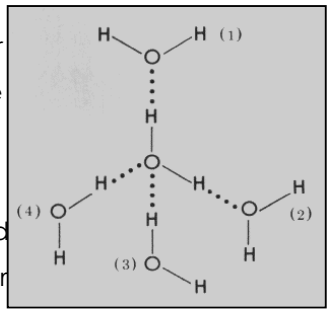
As can be seen from the diagram (right), Ionic substances such as sodium chloride, NaCl, are made up of positive and negative ions. Sodium chloride is held in it's structure by the strong attraction between it's positive sodium ions and negative chloride ions. Normally these ionic attractions require a large amount of energy to break but when put into water the negative oxygen side of the water molecules cluster around the positive sodium ions **Na^+** and the positive hydrogen atoms cluster around the negative chloride ions **Cl^-.** The attraction between the **Na^+** and **Cl^-** ions is weakened as the ions are separated. As the H_20 molecules have surrounded the **Na^+** and **Cl^- Ions,** they prevent the ions from joining back together and so keeping the substance in the solution



Water's property as a solvent is biologically important to life as most biochemical reactions such as respiration occur in solution. A medium, that is water, is required for the transportation, as reaction of certain substances. Blood plasma is mostly water. Blood is needed to transport vital substances around organisms. Water cannot dissolve hydrophobic substances such as fats and oils.

Water also has many thermal properties. It has a high boiling point, 100oC, which is unusual for a compound of such small molecular mass, (M_r H_2O = 18). Other molecules of similar size such as Carbon dioxide (M_r CO_2 = 44) are gas at room temperature where as water is a liquid. The water molecules have a weak, partial negative charge at one region of the molecule (the oxygen atom in water) and a partial positive charge elsewhere (the hydrogen atoms in water).

Thus when water molecules are close together, their positive and negative regions are attracted to the oppositely charged regions of nearby molecules. The force of attraction, shown on the diagram as a dotted line, is a hydrogen bond. Each water molecule is hydrogen bonded to four others. Individual bonds are weak but the sheer



number of them means that the total force keeping the molecules together is considerable.

As water has millions of hydrogen bonds, it causes it to have a high heat capacity. This means that water takes substantial heat to raise the temperature of water significantly but once warm, it cools slowly. This is essential to life where internal body temperature has to be maintained at a constant temperature and fluctuations can result in a breakdown of es sential processes. Large bodies of water will remain at an almost constant temperature with only very gradual changes, which makes temperature regulations for organisms far more straightforward. Because of the large number of bonds holding water molecules together, it takes 2 kJ per gram of water, which is a considerable amount of energy to separate the bonds and turn the liquid to vapour. Water is therefore described as having a high latent heat of evaporation. Animals use this property of water by using e xcess body heat to evaporate water from their surfaces, resulting in them transferring a lot of energy into the environment but only losing a little water. Sweating and panting are based on this principle.

Water's freezing property is also quite unique. Th e density of water when frozen (ice) at 0°C is less than liquid water. Most substances when turning from liquids to a solid usually become denser, as the energy in them is reduced, so they are held closer together, but this is not the case with water. As w ater cools, its density does increase. Hydrogen bonds between the water molecules take on a more latticed formation as ice. Yet ice floats on the surface of water, which means it's, density must be lower than that of water. Water is at it's most dense at 4 oC which is when its bonds are closest together. When water freezes the lattice arrangement of its structure move apart slightly and it floats on the surface. This means that the layer of ice insulates the water below which stays at 4oC and aquatic life ca n continue.

The last important property of water is that it has a high surface tension and cohesion. Surface tension can be seen in test tubes where we see a curved meniscus. This is due to hydrogen bonds causing a film of water to curve in the glass tub e. Surface tension is important for some insects such as water skaters and mosquito larvae that live on surface film. They are able to survive because the film allows them to be held above the water. Mosquito larvae hang upside down with the air

passage held above the water by surface tension. Its ability to survive depends upon the surface tension. Without it, the larvae would sink and die.

Cohesion is when things stick together, and are attracted to each other. Water molecules are attracted to each other by hydrogen bonds. If one molecule is pulled the neighbouring molecules as a result are also dragged along. Eg, if you apply pressure in a straw, all the water is pulled up. This is an important property as it enables water to be transported upwards, such as in plants. The ability of a plant to dissolve nutrients in roots and move them along the plant depends on water's property of cohesion.