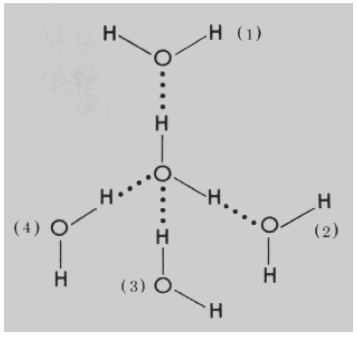
Helen Dickens 12SJL

Describe how the properties of water are related to its roles in living organisms and as a living environment for living organisms.

Over 70% of the world's surface is covered by water, 95% of which consists of salty oceans; water is essential to all life forms. A molecule of water consists of two hydrogen atoms covalently bound to one atom of oxygen which gives a formula of H_2O. 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 in the diagram below as a dotted line, is called a hydrogen bond. Each water molecule is hydrogen bonded to four others. It is these hydrogen bonds and the polarity of water molecules which are responsible for many of the unique characteristics and physical properties of water. Firstly, the attraction created by hydrogen bonds keeps water liquid over a wider range of temperature than is found for any other molecule its size. Secondly, the energy required to break multiple hydrogen bonds causes water to have a high heat of vaporization; that is a large amount of energy is needed to convert liquid water, where the molecules are attracted through their hydrogen bonds, to water vapour, where they are not.



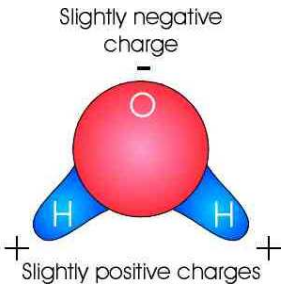
Water bonds itself to other substances very easily which is why some insects can glide on water. It also has a high surface tension which means that it is adhesive and elastic. This means that it sticks to the sides of vertical structures, for example it

allows plants to move water and dissolved nutrients from roots up to the leaves, and allows the movement of blood through tiny vessels in the bodies of some animals.

Water has a high specific heat and it can absorb large amounts of heat energy before it begins to get hot. This also means that, compared with air, water releases heat energy slowly when situations cause it to cool. Water's high specific heat helps organisms to regulate their body temperatures more effectively. Water vapour is a greenhouse gas, and both the capability to keep heat in and to transfer heat from the tropics serves to buffer temperatures on Earth. For example, as one-half of the Earth rotates away from the sun the fall in temperature is much more gradual than it would have been if there was no water vapour in the atmosphere.

As water expands when it freezes it allows ice to float on the surface which creates an insulating layer on lakes and rivers. This prevents the entire body of water and all the organisms living in it from freezing. The weak hydrogen bonding means that ice has a lot of empty space. When ice melts the "frozen" geometry is removed, but not all the hydrogen bonds are broken. The molecules begin to pack more closely together to fill some of the empty space. Thus, liquid water is denser than ice. Water has its greatest density at 4°C and this is why the top of a lake freezes first. The cooler part freezes and the more dense water at slightly higher temperature sinks to the bottom. This helps to protect fresh water organisms which live in the bottom. The empty space also means that ice does not conduct heat very well so the frozen top of the lake keeps the heat from the water below it from escaping too readily, maintaining it as liquid. This characteristic is central to maintaining aquatic life during winter.

Within the molecule of water the orbital shape of the covalent bond is slightly distorted, sometimes pushing the electrons closer to the oxygen atom. This leads to a small positive charge on the hydrogen and a small negative charge on the oxygen. This happens because the oxygen atoms have a greater likeness for electrons than hydrogen atoms.



As water is transparent and absorbs light rays very quickly it allows animals to see and aquatic plants to photosynthesise up to 600 feet below the surface. Water also absorbs light differentially. The red end of the light spectrum is absorbed in shallow water while the blues and greens penetrate the deepest. This is important for plants because different plants use different parts of the light spectrum for photosynthesis, and the differential absorption can determine the vertical distribution of marine plants. The low viscosity of the water allows organisms to swim and to transport materials through the body.

As a result of its polar nature (this means it has a negative end and a positive end as a result of the polar covalent bonds within the molecule) water is a solvent and readily interacts with other polar and charged molecules such as acids, salts, sugars and various regions of proteins and DNA. The water acts as a solvent for chemical reactions and helps to transport dissolved compounds into and out of cells. As a result of these interactions water can dissolve those substances which are consequently described as hydrophilic (water loving). In contrast, water does not interact well with non-polar molecules such as fats, oil and water, and the large polymers (e.g. polysaccharides and large proteins) do not mix. Non-polar molecules are hydrophobic (water hating).

Overall, water is necessary for almost all life forms on Earth, and without it almost nothing would be able to survive.