Water

Life as we know it would not exist without water (H_2O). Water serves as the universal solvent. Most of the molecules within cells must be dissolved in water to function. In fact, water is the most abundant molecule within cells and within the human body. Water comprises on average about 70% of a cell's weight. H.H. Mitchell et al. determined that the human heart and brain, two essential organs, consist of ~73 % water (The Journal of Biological Chemistry158, 625-637); even bones which have a high mineral content contain ~31% water. In addition to its essential function as a solvent, water in the human body serves to transport (plasma of blood) substances around the body; maintains and regulates body temperature; serves as a shock absorber for the brain (cerebrospinal fluid) within joints (synovial fluid) and around the fetus (amniotic fluid); assists with the elimination of wastes (urine); suspends enzymes (biocatalysts) and participates as a reactant in numerous reactions.

Water is composed of two hydrogen atoms covalently bonded to an oxygen atom. This combination of atoms and the bonding arrangement results in the formation of polar bonds. A polar bond forms when the electrons participating in the covalent bond are not shared equally between the atoms. This unequal sharing leads to the formation of localized charges (both positive and negative) associated with different regions of the molecule. Consider the covalent bond between hydrogen and oxygen. The oxygen atom is much larger and much more electronegative than the hydrogen atom. Oxygen pulls the shared hydrogen electron toward itself. The electron continues to move around the hydrogen atom, but 'spends more of its time' circling in the region between the two atoms. Because electrons are negatively charged, and the shared electron 'spends it time' close to the oxygen atom, the oxygen atom acquires a localized negative charge. Conversely, because hydrogen's negatively charged electron associates with the oxygen atom, the hydrogen atom acquires a localized positive charge. The presence of the localized positive and negative charges at opposite ends of the molecule is why this is considered a polar bond. Note: Non-polar bonds form when atoms participating in a bond share the bonding electrons equally, for example O_2 and N_2.

The polarity of water leads to the formation of hydrogen bonds. A hydrogen bond forms when water molecules orient themselves so that the localized positive charge on the hydrogen atom aligns with the localized negative charge on the oxygen atom. Remember opposite electrical charges attract each other! The hydrogen bond does not involve the sharing of electrons. Individually hydrogen bonds are very weak bonds, however when millions of these bonds form between molecules they produce a strong structure. So strong that they support the weight of insects like water striders, which walk on water. So strong that hydrogen bonds hold together the strands of DNA in your cells. The double helix is made up of two strands of nucleic acid. The bases, phosphate and sugar molecules in a single strand are covalently bonded together. The two strands however are joined to each other by hydrogen bonds that form between the nucleotide bases. This latter example exemplifies that hydrogen bonds don't just form between water molecules. Hydrogen bonds potentially can form between any polar molecules.

Water has several unique properties, most of which result from its polarity. Its ability to act as a solvent for example is the result of its polar nature. Water can dissolve just about any other substance and is particularly effective with other polar substances. Water is cohesive, meaning it is attracted to itself. The attraction of one water molecule to another produces surface tension. Water is also adhesive, meaning it is attracted to other substances. It has the ability to wet other materials. Adhesion and cohesion in

particular contribute to the phenomenon called surface tension. Water has a high specific heat. Specific heat is a chemical measure. The specific heat is the amount of heat that must be added to a solution to increase the temperature 1 degree Celsius. A high specific heat means that in order to change the temperature of water a lot of energy has to be added or removed. For life forms that means water in cells won't evaporate or freeze quickly. The final characteristic that is significant for life is the expansion of water when it freezes. The space between molecules in most substances decreases when the substance is frozen, therefore most compounds shrink or get smaller when frozen. However, when water freezes the distance between individual molecules increases as the molecules arrange themselves into an ice lattice. Frozen water in the form of ice is less dense than a similar volume of liquid water. That is why ice floats. Why is that important to aquatic plants and animals?