The Four Emergent Properties of Water
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The water molecule, by appearance, doesn’t look like much. Two hydrogen atoms and an oxygen atom make up the whole of the molecule. It is in this simplicity and the polar nature of the molecule that makes water such an amazing substance. A molecule of water is considered polar as a result of unequal sharing of electrons between the oxygen and hydrogen atoms. The electrons shared from the hydrogen atoms spend the majority of their time on the oxygen side creating a positive charge on the hydrogen atoms and a negative charge for the oxygen. This polarity creates the process of hydrogen bonding. Hydrogen bonding gives rise to the emergent properties of water.

There are four emergent properties of water. These are the unique properties of water that help to make life possible on this planet. The following is a list of the properties and a brief description of their importance to life.

1. The Cohesion of Water  The cohesion of water is the process of hydrogen bonding of water molecules to other water molecules. This property is essential in plants. The evaporation of water from the leaves of a tree, in effect, pulls on the other water molecules through their cohesive hydrogen bonds. This bonding extends to the roots of the tree pulling water directly from the soil. As the water travels up the tree vein the process of adhesion, the hydrogen bonding of water to another molecule, is employed to resist the forces of gravity.

2. Frozen Water Expands  When water freezes it becomes less dense than it is at its liquid form. This is important to prevent a runaway freezing effect on bodies of water. If water was more dense in solid form it would freeze at the surface and then sink to the bottom. This process repeated would consume all of the bodies of water with ice. Life in an ocean of solid ice would be difficult. However, frozen water is less dense than the liquid form, therefore it floats. Floating ice on bodies of water provide the additional benefit of insulation. The ice layer on the surface insulates the heat of the water below allowing for suitable water temperatures for life.

3. Water as a Solvent  The polarity of the water molecule make water a great solvent. Ionic compounds can be dissolved in water because of the negative charge of the oxygen atom and the positive charge of the hydrogen atoms. The water molecules surround the oppositely charged ions as a result of attraction to their polar charges. The water molecules create a hydration shell that separates the ions and the compound is dissolved. There are other nonionic polar molecules that can be dissolved in water. Water, as a solvent, is the essential substance in nearly all life functions.

4. The Moderation of Temperature by Water  A brief explanation of kinetic energy is important to the topic of moderation of temperature. Kinetic energy is the energy of motion. In a body of water the molecules of water are always moving. This movement of the molecules is kinetic
energy. Heat is the measure of a substance’s kinetic energy as a result of the movement of its molecules. If you add up all the kinetic energy of all the molecules in a body of water you get the heat of that body. This means that heat is determined by volume unlike temperature which just states the obvious regardless of volume. Taking this all into account large bodies of water like the Pacific Ocean have an awful lot of heat.

The next important concept is specific heat. Hydrogen bonding, once again, is at work providing water with an unusually high specific heat. The specific heat of a substance is the amount of heat that must be absorbed or lost in order to change the temperature of 1 gram of that substance 1 degree Celsius. So what is it about hydrogen bonds that make water special? First, the breaking of hydrogen bonds requires the absorption of heat. On the flipside the bonding process releases energy. The result is that as heat is added to water much of it is used in the breaking of hydrogen bonds and very little in raising the temperature of the water. In addition, as the water cools more hydrogen bonds form, releasing energy in heat.

To bring it all together we will look at the mild California coast. Temperatures along the California coast remain moderate for most of the year. The inland regions of the state fluctuate greatly the further from shore you go. The reason for this is the ocean’s ability to moderate temperatures. The process is as follows.

Heat is given off by the sun and is absorbed by the water as hydrogen bonds are broken. Slowly the water increases in temperature. At the surface, the “hottest” molecules of water can move fast enough to escape the liquid as a gas. This is called evaporation. As the fast molecules leave the surface of the water a cooling effect occurs in the absence of the heated escapee. As a result, the air is cooled through evaporation. At night the temperature drops. This causes hydrogen bonds to form. Heat is released from the hydrogen bonding into the air. This increases the air temperature. This process creates a continuous cycle of temperature regulation creating that wonderful mild climate.

Overall, water is an amazing substance. Its emergent properties explain just how important it is to all life on earth. In fact, just thinking about it right now makes me thirsty.