Water and the Fitness of the Environment
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Slide 1
A hydrogen bond does not form a compound, but it is a weak interaction between two polar molecules. Water is an example of a polar molecule, because oxygen has a much higher electronegativity than hydrogen. The polarity of water gives water many special properties. Because of these properties, it was chemically possible for life to begin on earth.

Slide 2
Hydrogen bonds can cause two types of attraction:

- Adhesion is attraction between two different types of particles.
- Cohesion is attraction between two particles of the same type.

Both of these types of attractive forces allow water to reach the top of a tall tree, despite the force of gravity pulling the water downward. Adhesive force attracts water to the walls of vessels in the tree, pulling the water upward. Cohesive force attracts water molecules to other water molecules, so when water molecules are moved upward, other water molecules are drawn along for the ride like boxcars in a train.

Slide 3
Hydrogen bonding causes surface tension in water. Water molecules in the depth of a volume of water are attracted by other water molecules from all directions equally. But water molecules at the surface are attracted only to water molecules below them (since there aren't any above them). This compresses the surface layers of water molecules, forming a skin-like layer of higher density.

Slide 4
Two points are illustrated in this slide:

- Specific heat capacity is defined as the amount of energy required to raise the temperature of a specific amount (e.g., one gram) of a substance by a specific amount (e.g., one centigrade degree). Because of hydrogen bonding, water has a high specific heat capacity, which means that water is relatively hard to heat or cool. As a result, a large body of water (like the ocean water at a shoreline) heats and cools much more slowly than the adjoining land mass, keeping the temperature of the ocean water (where life began) much more steady than the temperature on land.
- Latent heat of vaporization is defined as the amount of energy required to convert a specific amount (e.g., one gram) of a substance from the liquid state to the gaseous state. Because of hydrogen bonding, water has a high latent heat of vaporization, which means that it is harder to evaporate a given amount of water than it is to evaporate the same amount of most other liquids. When water evaporates, both the remaining water and the air into which water is evaporating are cooled. Therefore, air temperatures tend to be lower near large bodies of water, and sweating (which is evaporation) cools the body that is sweating.

Slide 5
Water is very unusual in that it has a lower density as a solid than it does as a liquid. This is because hydrogen bonding causes the water molecules to become arranged in a way that puts a lot of space between molecules. Freezing locks those molecules in that position, so water expands when it freezes. Because of the decreased density compared to liquid water, ice floats. Therefore, bodies of water (which contain life) freeze at the top and remain liquid at depth throughout the winter. This allows the organisms to continue to live. If a body of water were to freeze at the bottom and then upward, the ice from one winter would not completely thaw the next year, and the thickness of the ice would increase annually until the entire depth would freeze.

Slide 6
A solution is a mixture in which a substance, called the solvent, dissolves one or more other substances, called solutes. Water is an excellent solvent, because it is a polar molecule. Salts, for instance, dissolve easily in water, because the partial charges of water molecules attract ions away from the crystal to which they belong. Both cations and anions become surrounded by water molecules, keeping the ions from reforming ionic bonds.

Slide 7
Even some non-ionic compounds (like the protein shown in this slide, for instance) can be dissolved in water. A protein can have parts of its surface that are positively charged and parts that are negatively charged. Water molecules arrange themselves so that negative water charge is situated next to positive protein charge, and vice versa.

Slide 8
In a given volume of water a very small fraction of the water molecules undergo a reaction called autoionization. In autoionization, one water molecule loses the proton of one of its hydrogen atoms, and that proton is received by a different water molecule. This turns the molecule that lost the proton into a hydroxide ion (OH^-), which is negatively charged, because the electron that the hydrogen was sharing with the oxygen gets left behind with the oxygen. The other water molecule, which receives the proton, turns into a hydronium ion (H_3O^+), which has a positive charge, because it now has an additional proton. In pure water, the number (or concentration) of hydrogen ions always equals the number (or concentration) of hydronium ions, so water is neutral. In an aqueous solution in which the concentration of hydronium ions does not equal the concentration of hydroxide ions, that solution is either acidic or basic, depending on which type of ion predominates.

Slide 9
The pH scale is a logarithmic scale devised to denote the degree of acidity of basicity (alkalinity) of a solution. An acidic solution is one that has a higher concentration of hydronium ions than hydroxide ions. A basic solution has a higher concentration of hydroxide ions than hydronium ions. The mathematical definition of pH is:

$$pH=-\log[H_3O^+]$$

In pure water, because of autoionization, the concentration of hydronium ions is 10^{-7} M. Therefore, the pH of pure water is 7. A solution with ten times the concentration of hydronium ions (compared with water) has a hydronium ion concentration of 10^{-6} M. Therefore, its pH is 6. Notice that as hydronium ion concentration (and therefore acidity) increases, the pH decreases. Basic solutions have pH values greater than 7.

Slide 10
Many household substances have pH values far from neutral.

Slide 11
Part of homeostasis is keeping the pH of intracellular and extracellular fluids within narrow ranges. The pH cannot be allowed to change greatly, because even a moderate change in pH can cause a drastic change in the shape (or conformation) of proteins. When proteins change shape, they stop working, and the organism dies. This is why, for example, the pH decrease caused by acid rain is so detrimental to the living organisms in the areas exposed to acid rain.