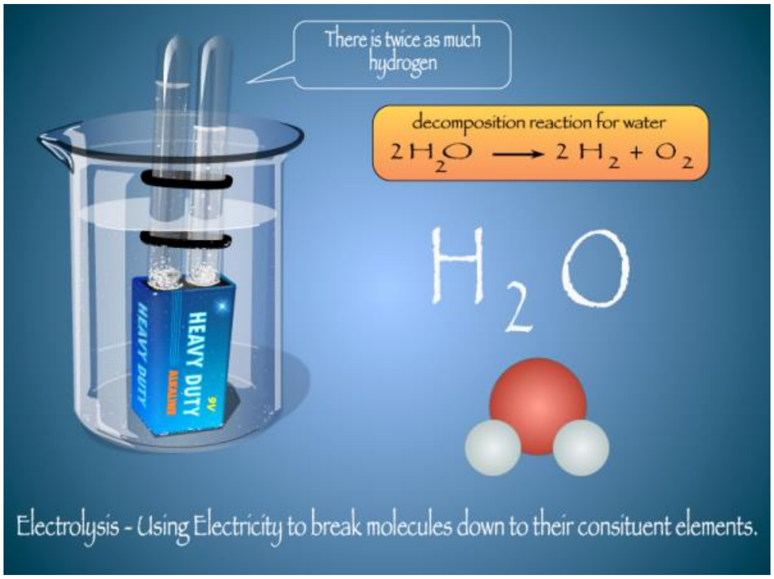
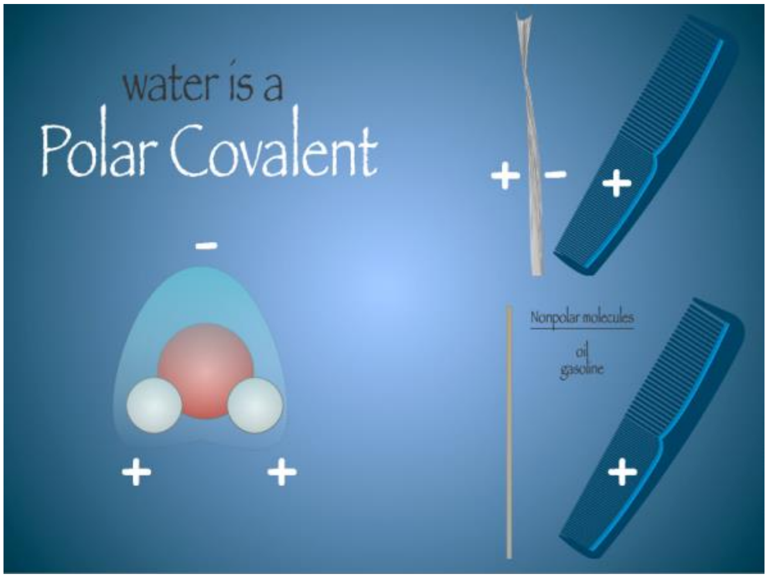
Water

Saturday, October 20, 2012
10:38 PM

Slides	Notes
	
	Electrolysis is a way to break down molecules into their constituent elements. Water does something interesting when it is exposed to electricity. It starts to bubble. You can even check it our yourself with this little experiment. There will be bubbles of gas that rise up from each of the terminals of the battery. What you may not realize is that the gas is different in one tube compared to the other one. You can take a splint and test each gas you collect. In the tube with twice as much gas, you get a pop sound when you stick a splint in to the tube. That is a characteristic of hydrogen gas. With the one with less gas, the splint will relight. That is a characteristic of oxygen gas. Since there is twice as much hydrogen we know the atoms making up water will have two atoms of hydrogen for every one of oxygen. You can tell that is the case by the molecular formula for water too. The little subscripted 2 right after the H for hydrogen indicates there will be two atoms of hydrogen. There isn't a little subscript after the O for oxygen. When you don't see a subscript number, you assume it means 1. There is one atom of oxygen for every molecule of water. So, whenever you see a molecular formula for any substance, you can identify how many atoms of each there are of each molecule.

Here we have a lab set up in which we are going to test water and oil's behavior around a static charge. We can build up a static charge with a balloon or a plastic comb rubbed against clean dry hair. The comb will give many electrons to your hair leaving the comb to be more positively charged than is normal.

Click on a bottle to test each liquid and note how the static-charged comb impacts the liquid.



Why did the water bend toward the comb and the oil not react at all?

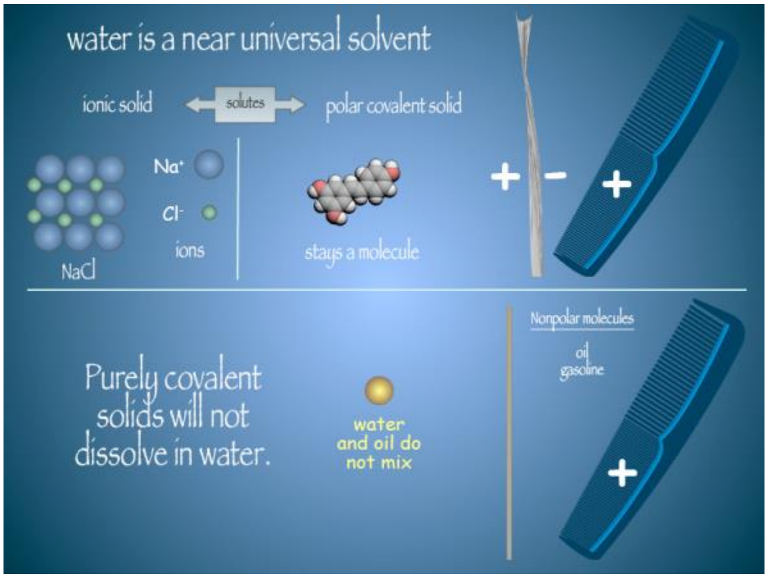
The hydrogen and the oxygen atoms in water are sharing electrons in a bond between them. That makes water covalent. But, oxygen is a little more hungry for an electron than either of the hydrogens. The result is that the side of the molecule where oxygen is will have the electron more of the time making that side slightly negative in charge. That makes it polar. So water is a polar covalent substance. The main elements that will be electron hungry, or electronegative, and most often makes a polar covalent combination with hydrogen is oxygen, chlorine, and fluorine.

Any other molecules or objects with a charge then will respond to that imbalance of charge that water has. It is a lot like what you experience with a magnet. If you bring the North and south poles near each other the magnets are attracted to each other because one side is negative and the other side is positive. That is what is happening with the comb.

Well then why doesn't the same thing happen with the oil then? Have you noticed that not everything responds to a magnet? You can bring a magnet near metal paperclips and they will stick to the magnet, but if you bring ordinary paper toward it neither one seems attract or repel. That is because not everything has an imbalance of charge and so those things ignore charges of other substances. That is the way oil is. Its molecules have electrons that are shared in such a way that there isn't a place that is more positive or more negative on the outside of it.

Another non-polar liquid besides oil is gasoline. All three, water, oil, and gasoline are covalent, but only water is polar covalent. Sometimes when something is just covalent and not polar, it is said to be purely covalent.

Have you ever noticed that if someone gets oil, grease, or gasoline on their hands, they cannot just wash it off with water? You have to use soap. That takes us to the next characteristics of water.



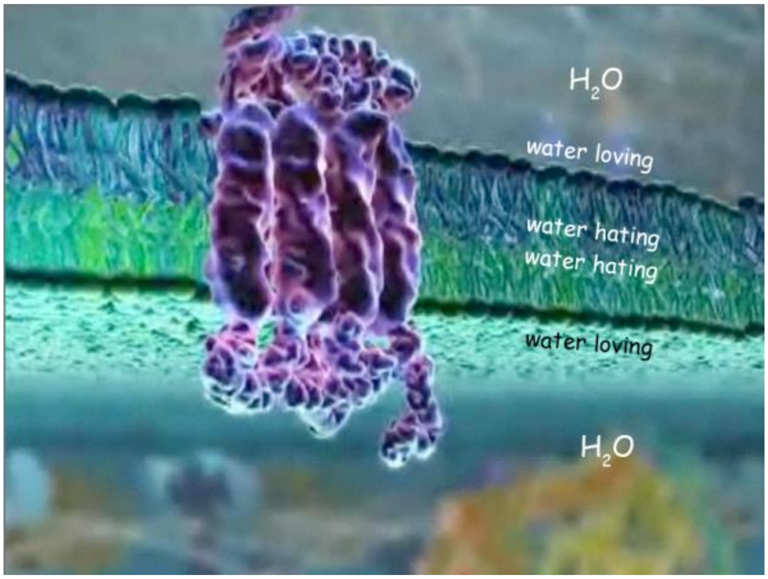
Water is a near universal solvent. That means that it can dissolve a lot of things in the world. Far more than most molecules. It can dissolve ionic and other polar covalent substances. What is ionic? Ionic substances also have an imbalance of charge like water has. If you toss some salt in water, the cube breaks down and disappears because the water dissolves it. Water is a solvent. That means it does the dissolving. Salt is the solute because it is what gets dissolved.

How does water dissolve the ionic compound, salt? The positive and negative charges of the water are attracted to the positive and negative regions in the salt cube's lattice of sodium and chlorine. It can surround the salt atom's and pull them away. What results is sodium ions that are positively charged and chlorine atoms that are negatively charged floating around in the water. Water is competing and they are just as attracted to the water molecules.

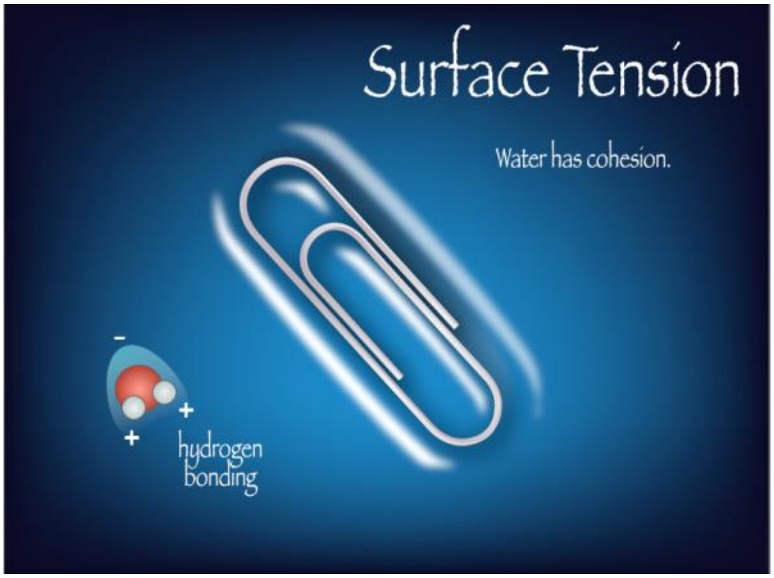
OK, so now we understand how the ionics get dissolved. What about other polar covalent substances? Those get surrounded by water molecules and get pulled out of their crystal lattice too , but instead of ending up as ions these molecules stay together because they have the best friend forever kind of bonds holding their atoms together instead of just hanging out together.

Remember that the oil and the gasoline cannot dissolve in water alone? It takes soap in addition to the water. Oil and gasoline have no imbalance of charge for water to be attracted to for its surround and pull tactic.

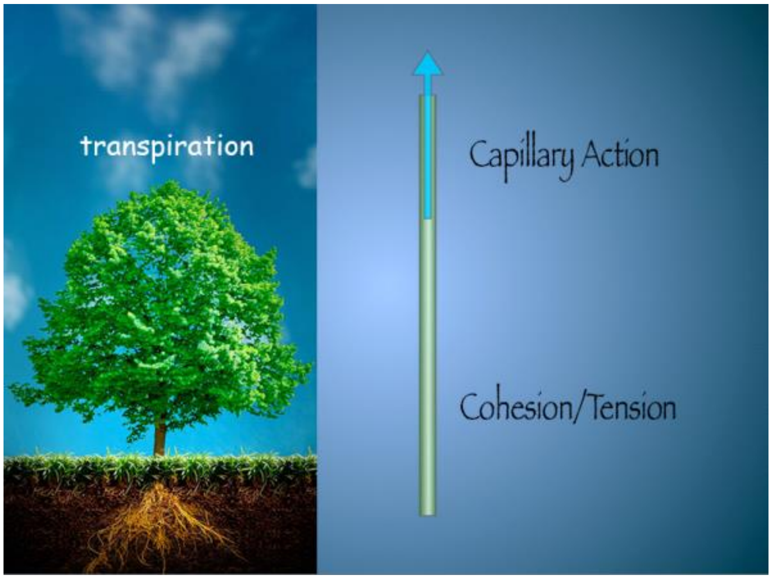
There is more to it than that even. Oil molecules have a structure where a portion of the molecule loves water, hydrophilic, and a portion that hates water, hydrophobic. It is different than the charges, but it creates that interesting phenomenon where oil will form up little spheres when in water. The parts of the molecule that love water face outward while the parts that hate water hide inward. If you have ever observed the behavior of your Italian salad dressing, you are all too familiar with the meaning to the phrase oil and water don't mix.



This is a really important characteristic for your cells. The 'skin', or cellular membrane, of your cells are made up of the same type of molecule as the oil in your salad dressing. This makes that membrane work. Its water loving side of the molecule points to the outside and inside of the cell that has water. The side of the molecule that is water fearing faces inward. It makes for two layers that can self heal if it gets disturbed - sort of like plastic balls on the surface of a pool will close a gap back up caused by someone jumping in to a pool covered in floating balls.

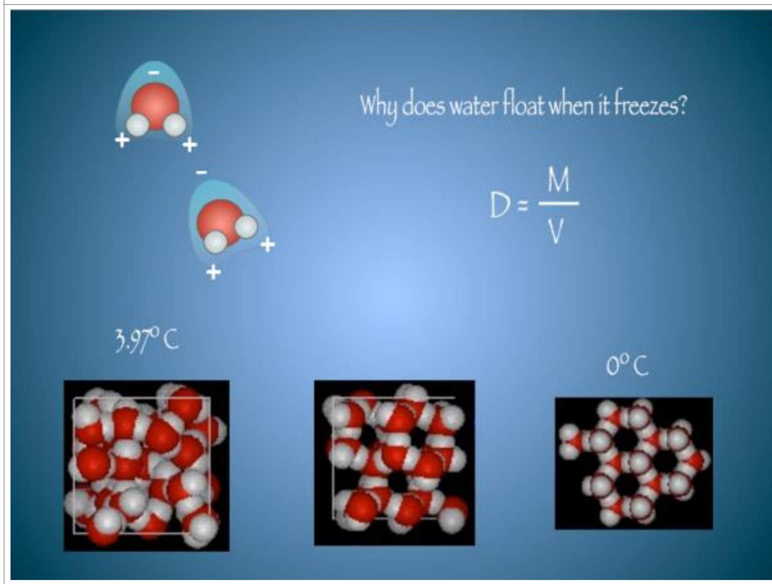


Though the internal bong between the hydrogens and the oxygen are strong, there is an attraction of hydrogen atoms to other hydrogen atoms called hydrogen bonding. It makes water molecules hang on to each other at the surface of liquid water. It hangs on tight enough that light objects with enough surface area can be made to float even when their densities are bigger than that of water. Water bugs and paperclips can float on the water so long as nothing disturbs the water tension. A drop of soap will break the surface tension and down the paperclip will go.



The way water likes to stick to itself, cohesion, is how water can go up plants against gravity without a heart to pump it up the plant. The water evaporates off of the leaves. As one molecule of water leaves there is a tug upward. Since each molecule of water likes to stick to the next one in the vessels of the plant they all move up a space just as if they were waiting in line for the show. This is called capillary action. If you have a really thin, hollow glass tube, about the diameter of a coffee stir stick, you would see the very same thing happen if you put one end in the water. The water will zoom up the tube an as one molecule evaporates away the next takes its place.

Animals use water cohesion in many ways too. One way is in the lungs. Water cohesion gives your lungs tiny alveoli a little spring back force after you inhale to make the exhale a little easier. There are other substances in your lungs that counter the cohesion just enough so that the membranes in the lungs don't stick together. If you have ever played with water balloons, you may have noticed that a bit of water in the balloon makes the sides of the balloon stick together. That wouldn't be good to have that in the lungs.



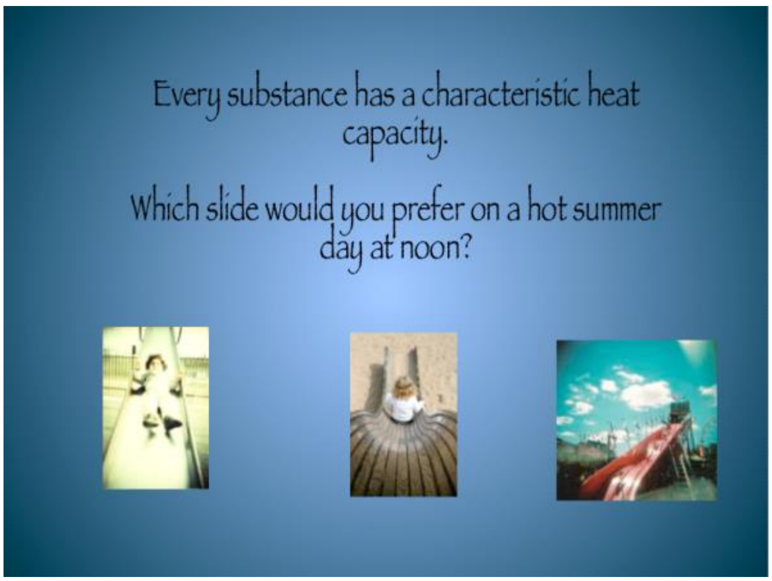
For most substances, when they get cold they contract. Their volume becomes less. Water is unusual in that it actually gets bigger when it gets cold enough to become a solid. Why?

It all has to do with the way the way water is polar. As the water gets colder they slow down. They start getting close to each other. They pack the closest at 3.97 degrees Celsius. That is actually a little bit above freezing. As they get close the positive and negative charges begin to make the molecules orient toward each other in such a way that they begin to form a crystal lattice of sorts. The way they line up forms a geometric pattern that has air spaces in them causing the volume to increase.

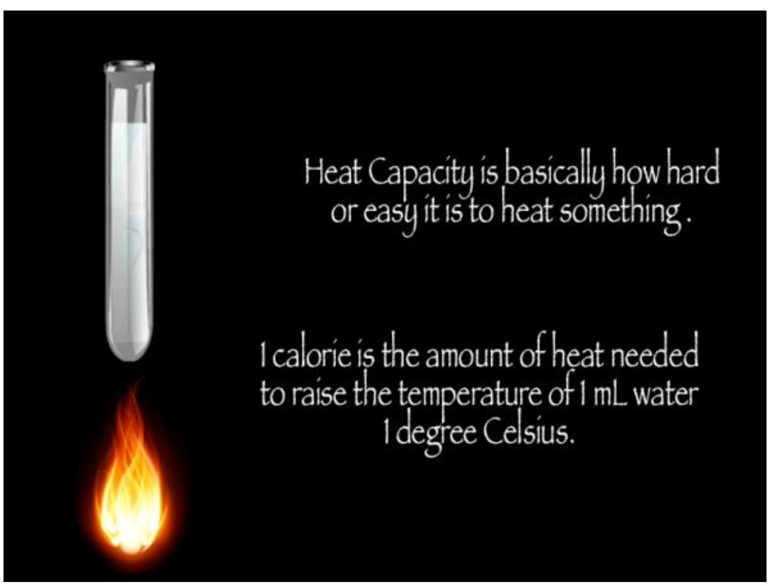
OK, now why does the increase in volume make ice float on top of the water? Density. Density is the relationship the mas to the volume as you see in the density equation of $D = M/V$. If the value for volume gets larger the D will get smaller. Whether an object will sink or float comes down to if the object is more or les dense than the liquid it is in. If the object is less dense, then it floats.

The ability of water to absorb and carry away heat is how sweating makes you cool off on a hot day if the humidity isn't too high. It is also when some machines have water flowing through them. The water absorbs the heat and the heat then can be taken to a radiator with a fan to speed up the water giving the heat to the air.

Water vapor in the atmosphere heats up too. Humidly will increase as water vapor level increase. The heat being carried away from lakes, creeks, streams, and people sweating moves in to the air. A hot day with a lot of humid air hitting a mass of cold dry air can get all swirling and mixing to the point of a big thunderstorm as the cold air brings the water vapor into larger drops to make big storm clouds.



Ask students why they would avoid the metal one after they have a chance to answer the question.



Heat capacity is how hard or easy it is to heat something. Water can absorb heat . It takes about 1 chemistry calorie to heat up one milliliter of water one degree. A chemistry calorie isn't exactly the same kind of calorie like you see on food packages. It takes 1000 chemistry calories to make 1 food calorie. In chemistry, you always use a lowercase c for calorie when you are talking about chemistry calories so you can tell the difference.

When you sweat, the water is absorbing the heat from your body and as the water gets warm enough to evaporate off of your skin it carries the heat away with it.

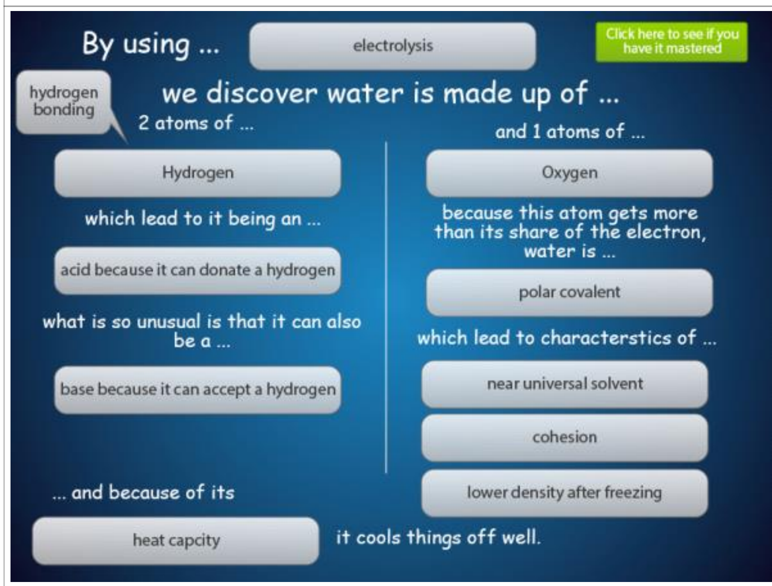
Since water has hydrogen, it can act as an acid because it can donate a hydrogen. The odd thing about water though is that it can also accept a hydrogen, so it can also act as a base or alkaline substance. Very few substances can be both. Though, water is a pretty weak acid or alkaline. It is pretty neutral giving it a chance to stick one hairy toe over the line either way when it wants to.

What are acids and bases? Acids are hydrogen ion donators. When a substance is an acid, it will taste sour. You probably like eating a few sour, acidic foods. Oranges have a lot of vitamin C in them. Another name for vitamin C is ascorbic acid. What other sour foods do you like?

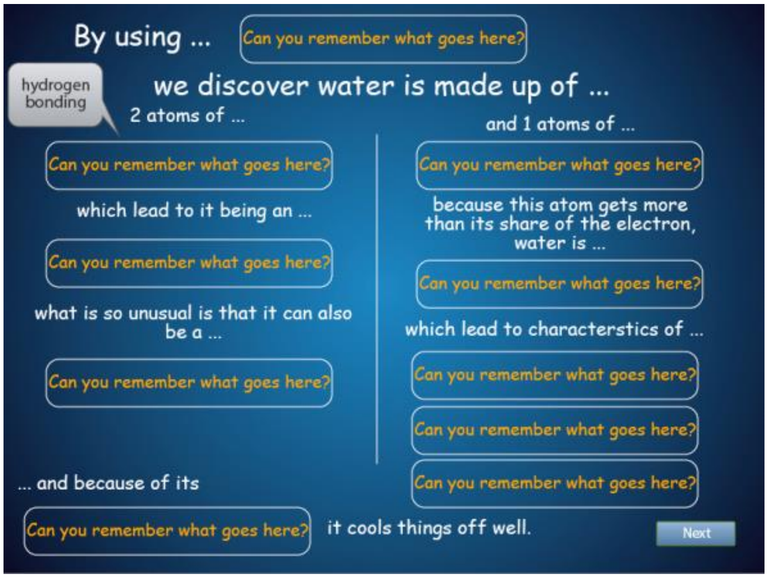
Bases are hydrogen ion acceptors. They will taste bitter and can feel slippery when they are dissolved in water. Soap is usually alkaline, or base. It feels slippery when wet. Many medicines are alkaline , or basic. If you have ever had the misfortune of having an aspirin dissolve on your tongue before you could swallow it, you definitely know that is some bitter stuff.

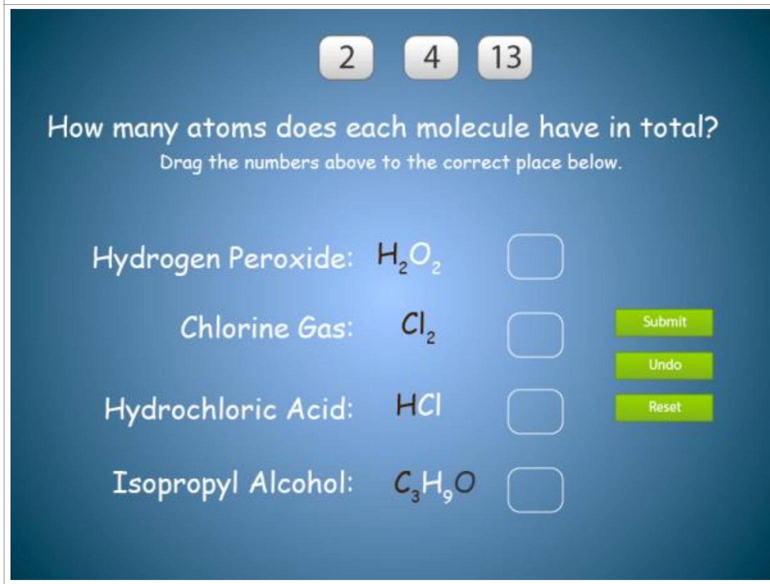
A fun way to play around with acids and bases is to boil some red cabbage (it actually is purple in color, not red). Collect the juice. It will change colors depending on the pH of the substance you test. The pH is a scale that measures how acidic or basic something is. Try all kinds of foods and bathroom liquids and lotions to see what color you get.

Our bodies are made up of a lot of water. Take a look at the percentages.

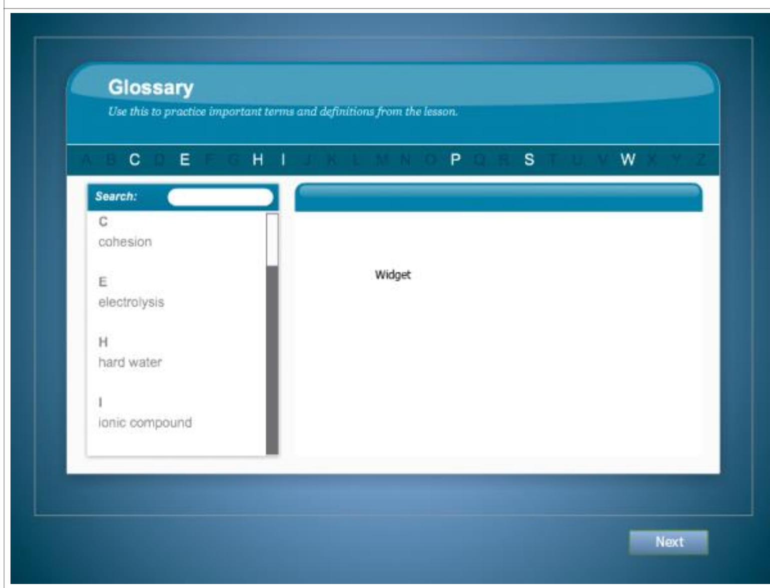


Study this summary page and then click to go to the next page to see how much you remember.





Tip:
Each element begins with a capital letter.



Cohesion
A phenomenon that occurs when individual molecules are strongly attracted to each other

Electrolysis
The use of electricity to break molecules down into smaller units

Hard water
Water that has certain dissolved ions in it such as calcium and magnesium

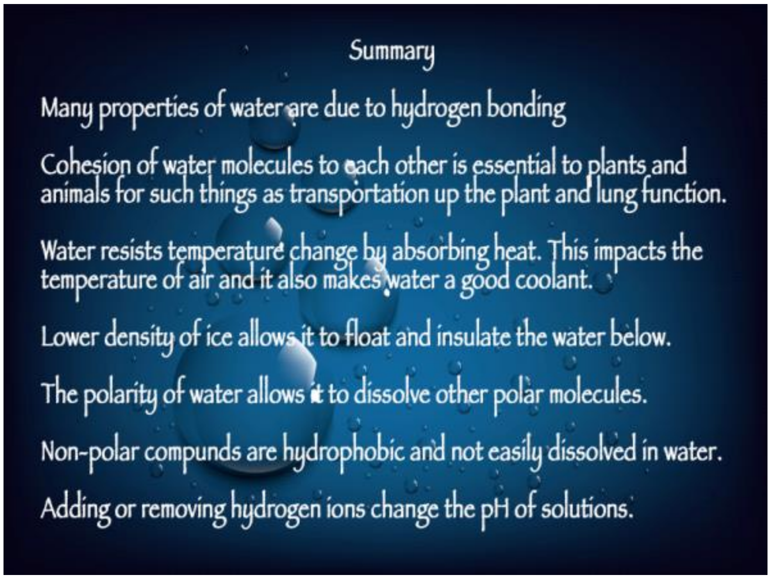
Ionic compound
A molecule that is a mix of metal and non-metal elements.

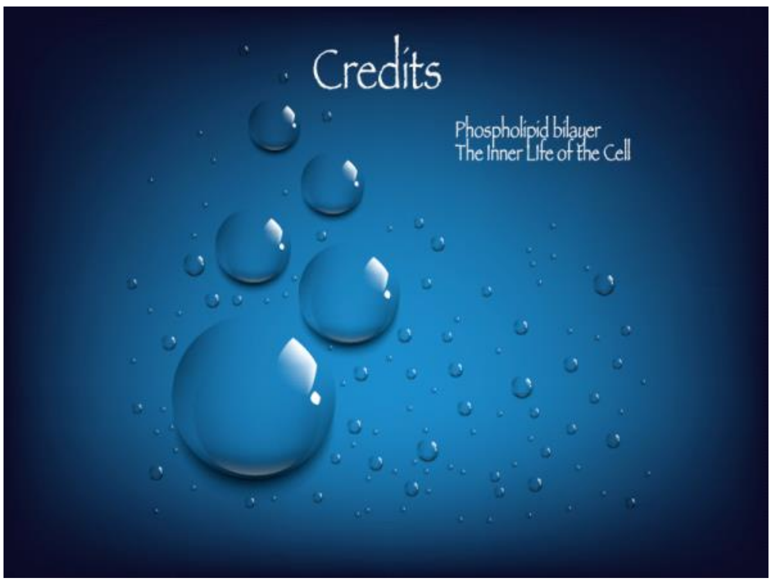
polar molecule
A molecule that has a slight positive charge in one location on the molecule and a slight negative in another

Solute
A substance that is dissolved in a solvent

Solvent
A substance that dissolves other substances

Water (as a solvent)
A near-universal solvent


Summary
Many properties of water are due to hydrogen bonding
Cohesion of water molecules to each other is essential to plants and animals for such things as transportation up the plant and lung function.
Water resists temperature change by absorbing heat. This impacts the temperature of air and it also makes water a good coolant.
Lower density of ice allows it to float and insulate the water below.
The polarity of water allows it to dissolve other polar molecules.
Non-polar compunds are hydrophobic and not easily dissolved in water.
Adding or removing hydrogen ions change the pH of solutions.


Credits
Phospholipid bilayer
The Inner Life of the Cell