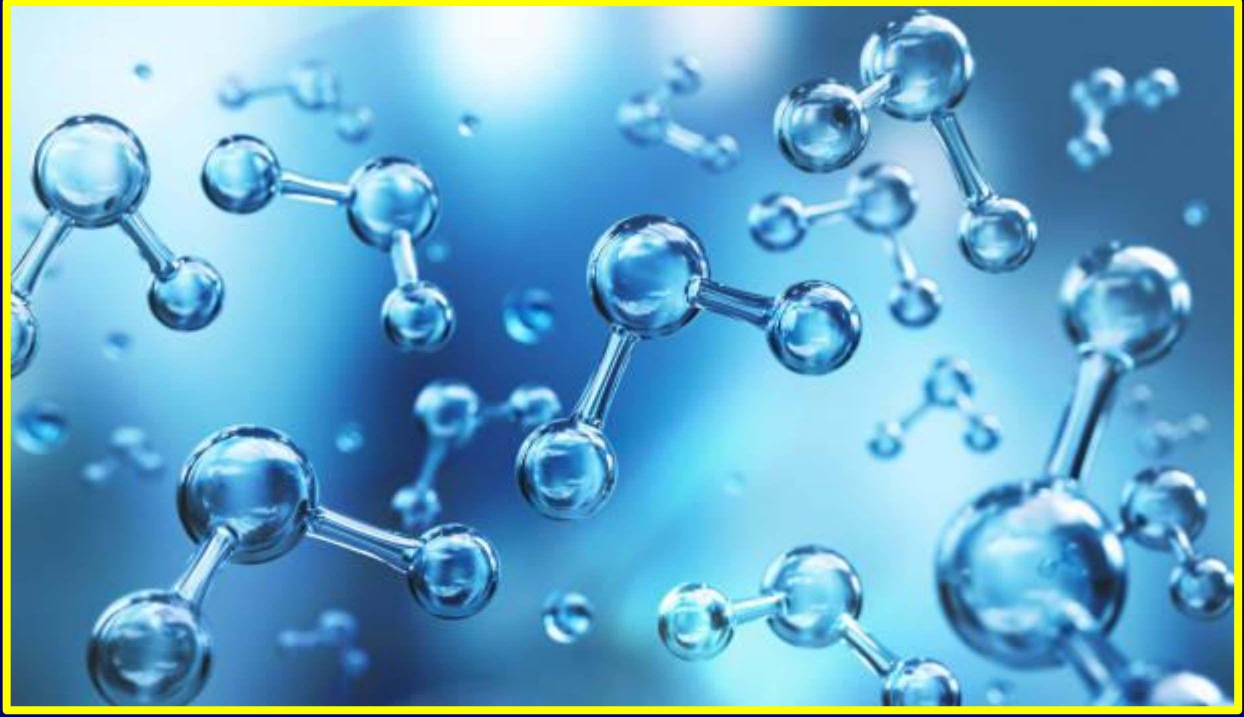
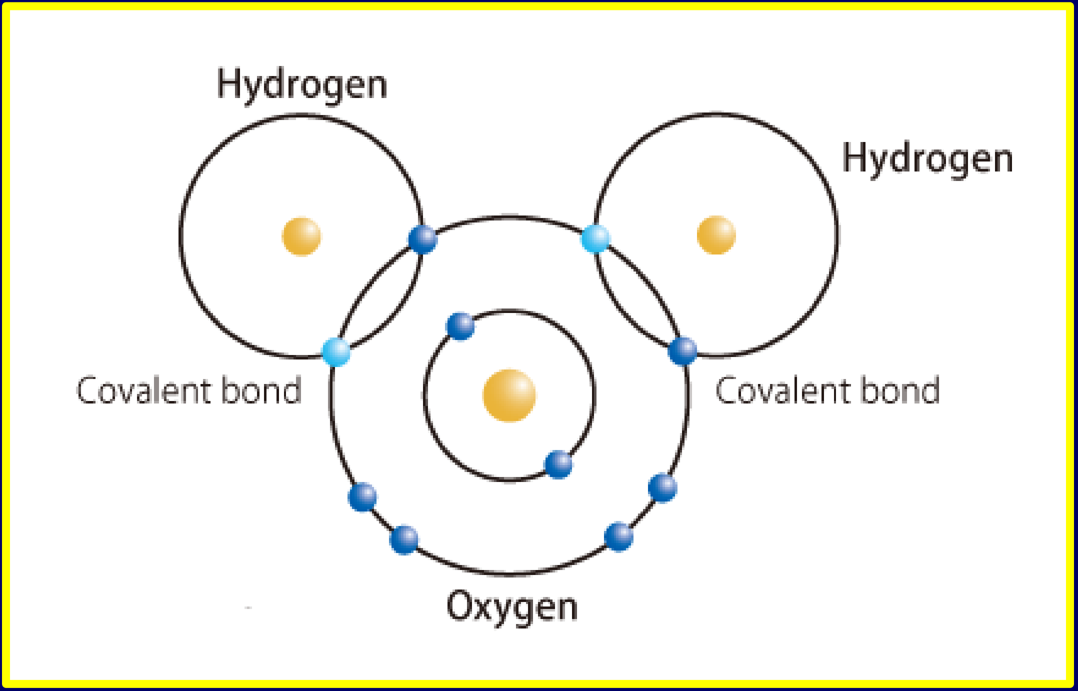
Properties of Water



Water Molecule

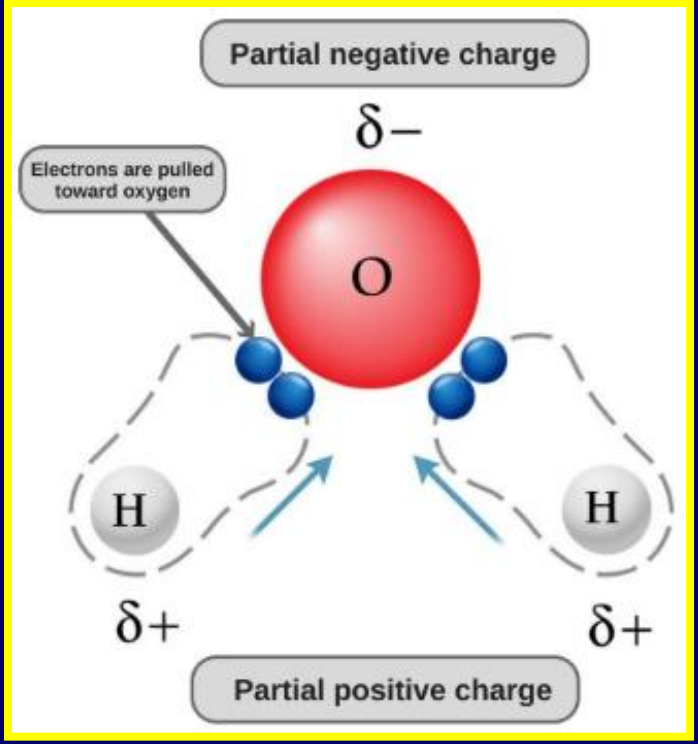
A water molecule consists of one oxygen atom covalently bonded to two hydrogen atoms.

H_2O



Polar Molecule

Because the oxygen is larger with 8 positively charged protons, the electrons are more attracted to the oxygen atom.

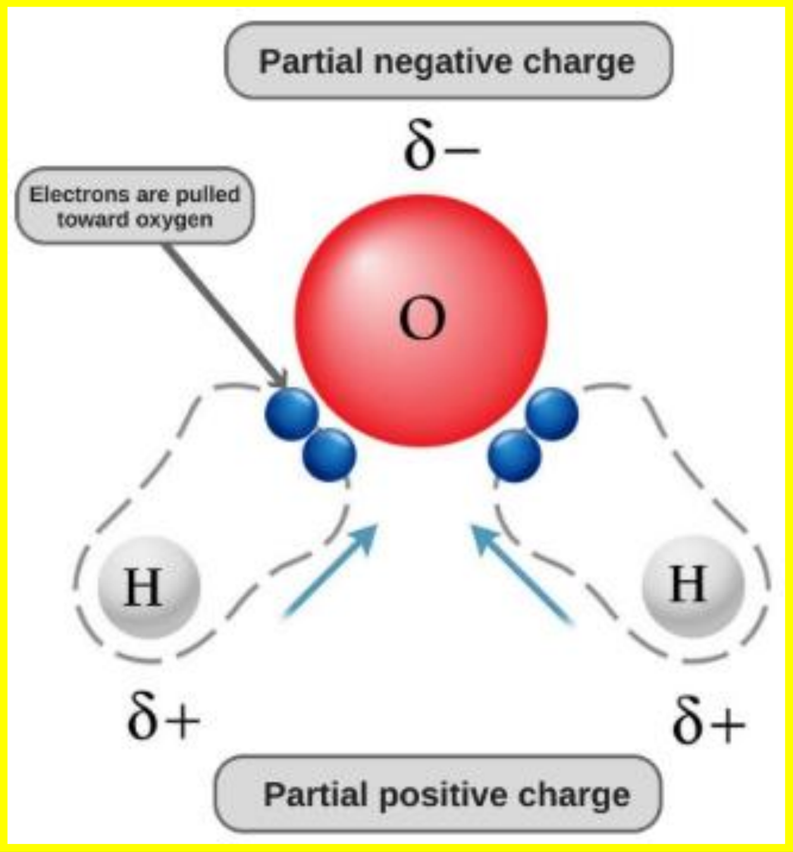


This results in the oxygen atom developing a partial negative charge.

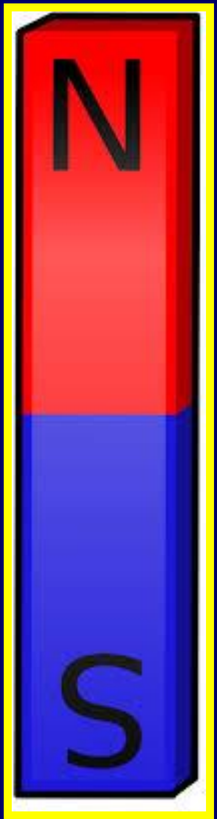
This leaves the hydrogen atoms with a partial positive charge.

Polar Molecule

The symbol δ stands for slight, meaning that it is not fully positive or fully negative.

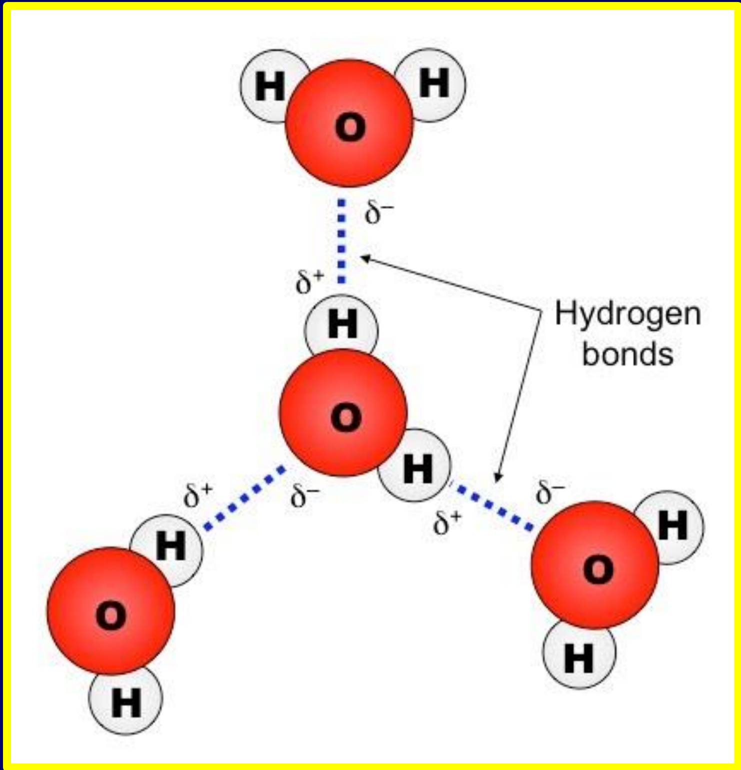


Both sides of the molecule have opposite charges, it is called a polar molecule.



Hydrogen Bonds

The polar nature of water molecules allows each molecule to form hydrogen bonds with other water molecules.



Each O δ^- atom from one water molecule, form a weak bond with a H δ^+ atom from another water molecule.

Unique Properties

The polar nature of water molecules, along with their hydrogen bonds, is responsible for most of water's unique properties.

Universal Solvent

Adhesion

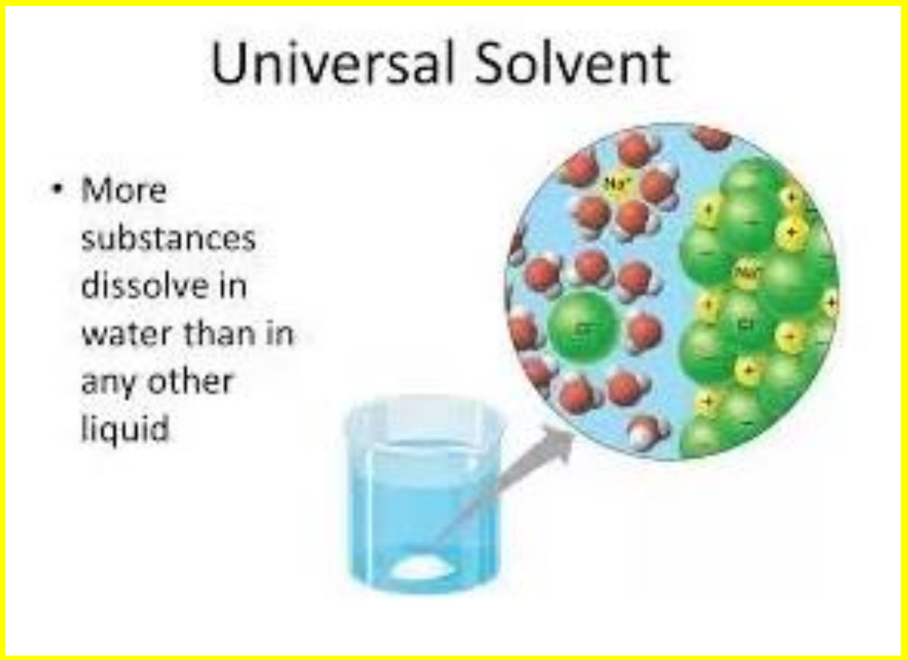
Cohesion

High Heat Capacity

Less Dense as a Solid

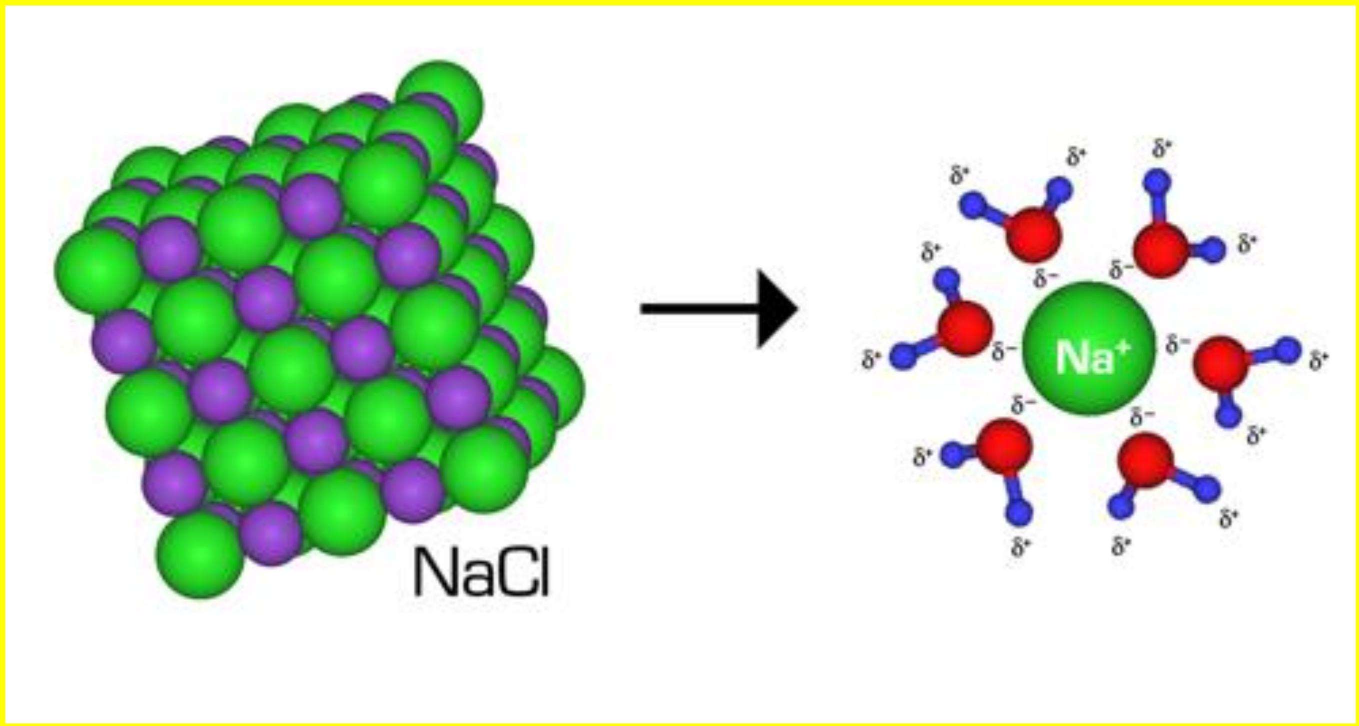
Universal Solvent

The polar nature of water molecules helps it dissolve other polar molecules as well as ionic compounds, making it a universal solvent.



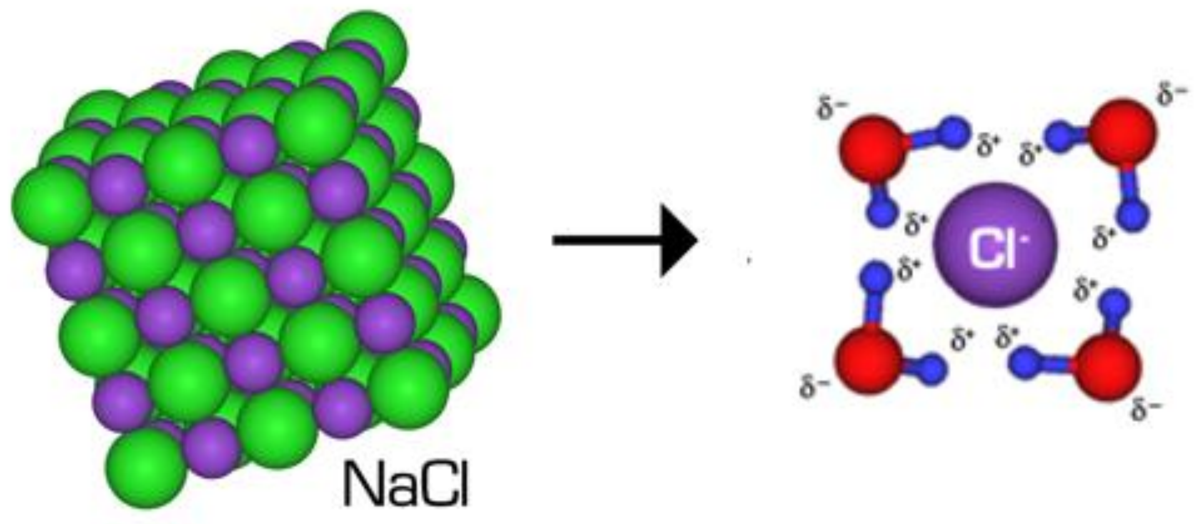
Polar Dissolves Polar

When salt, NaCl, is placed in water, H_2O, the O atoms from the H_2O, with a δ^- charge, surround the Na^+ atoms from the NaCl compound.



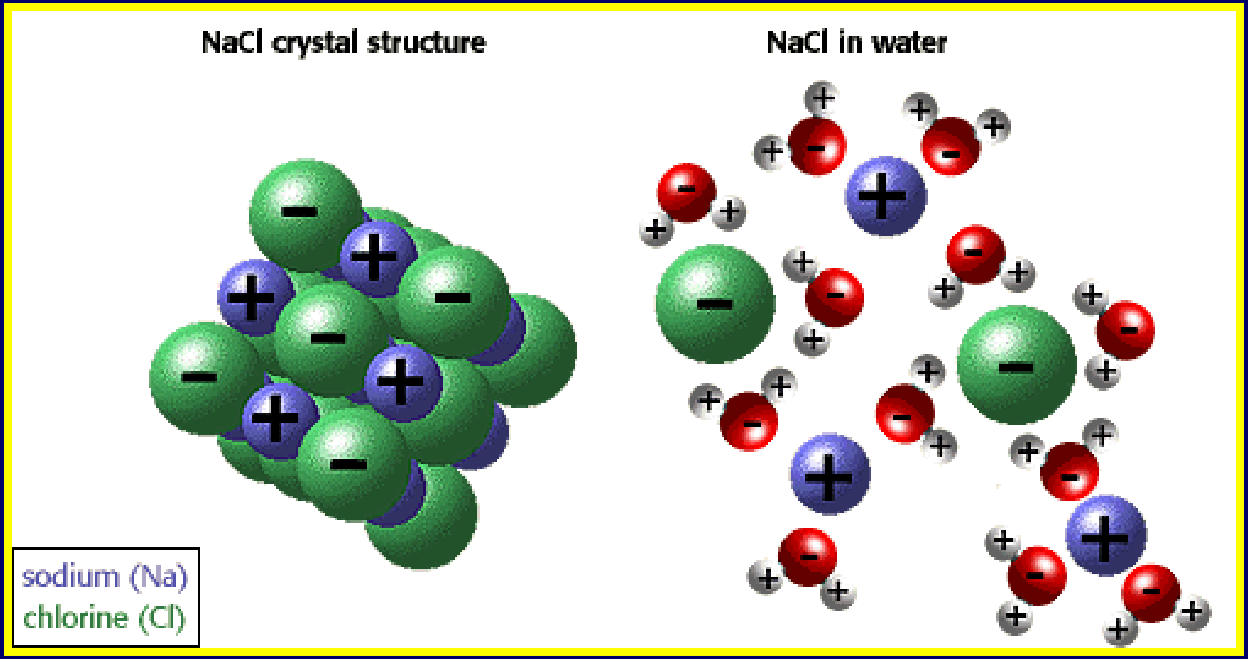
Polar Dissolves Polar

At the same time, the H atoms from the H_2O, with a δ^+ charge, surround the Cl^- atoms from the NaCl compound.



Polar Dissolves Polar

Overtime, the salt compound is pulled apart and dissolved within the water molecules.



Salt – Solute

Water - Solvent

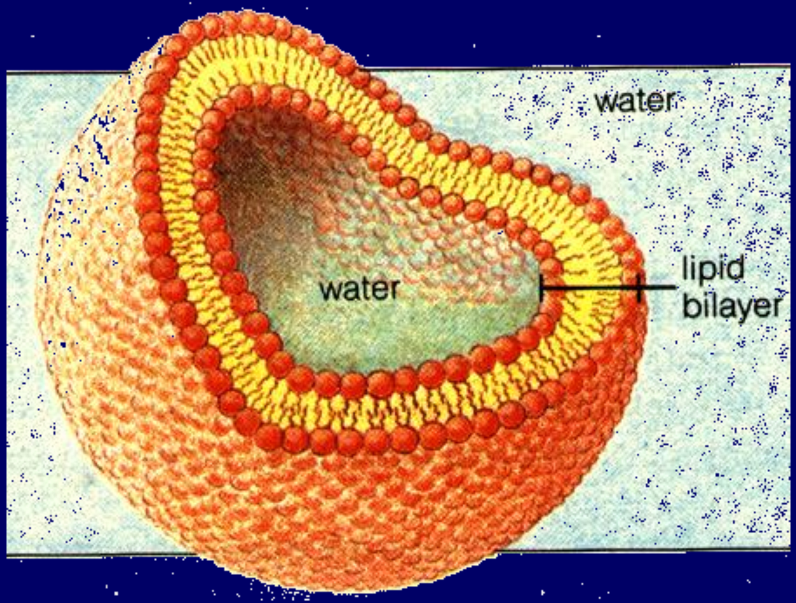
Nonpolar Molecules

But water cannot dissolve everything.

For example, water cannot dissolve lipids, like oils and fats because they are nonpolar and there is no electrical attraction.

Lipid Membrane

Our bodies are made up of individual cells that are 70% water.

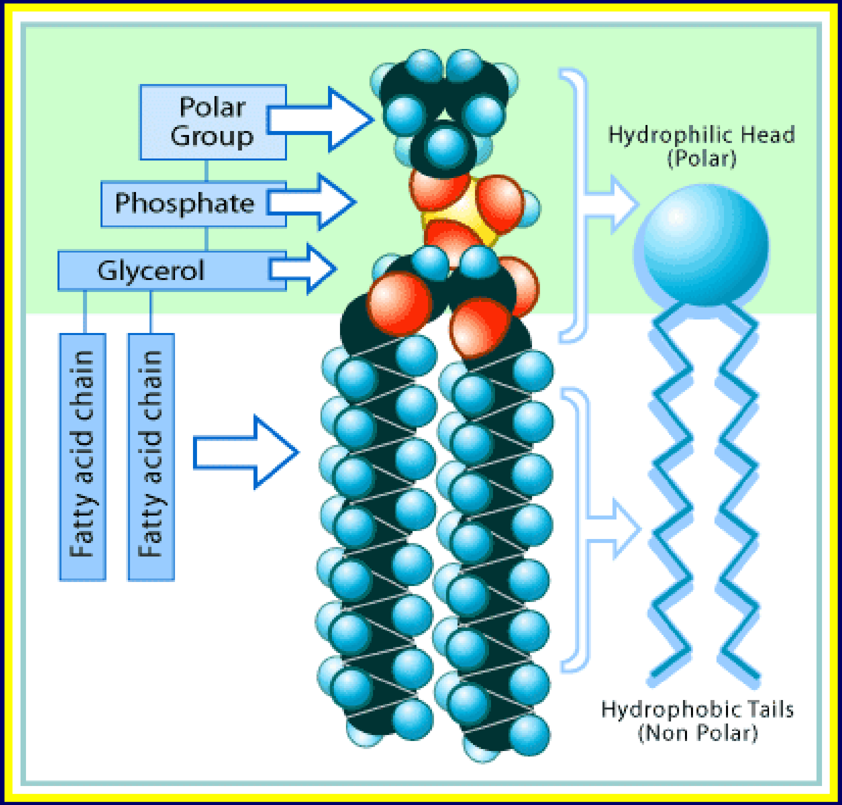


And most of our cells are surrounded by water.

However, each of our cells is surrounded by a cell membrane made up of special lipids, called phospholipids, which keep the cell intact.

Phospholipids

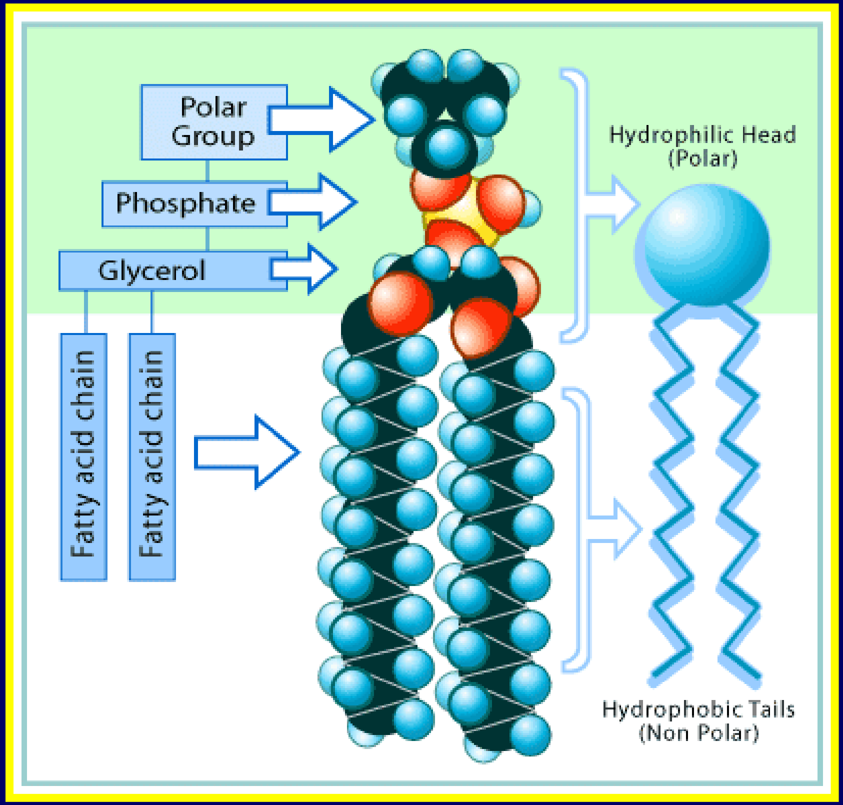
Phospholipids that make up cell membranes have polar heads and non-polar tails.



The polar phosphate head is attracted to polar water molecules, so it is called hydrophilic, meaning water liking.

Phospholipids

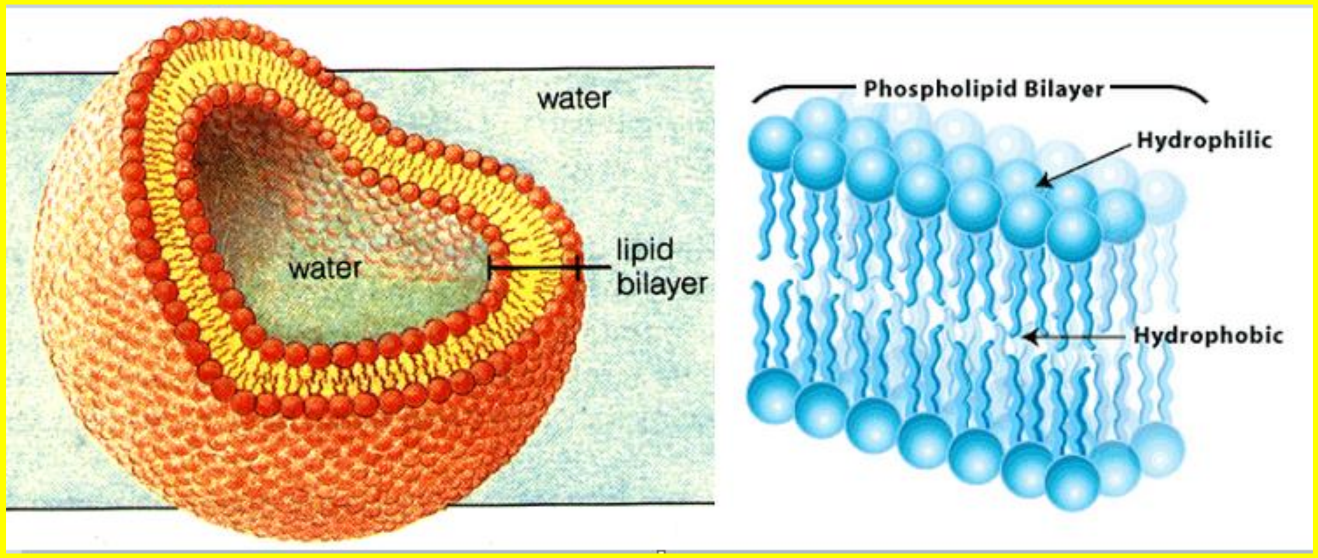
Phospholipids that make up cell membranes have polar heads and non-polar tails.



The nonpolar lipid tails are not attracted to polar water, so they are called hydrophobic, meaning water fearing.

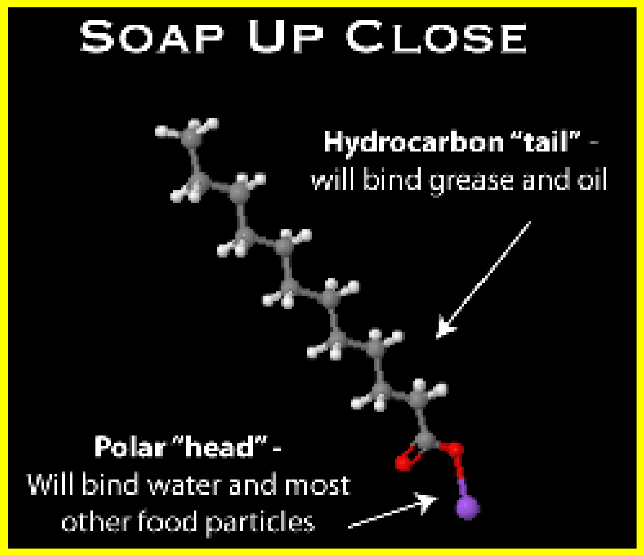
Lipid Membrane

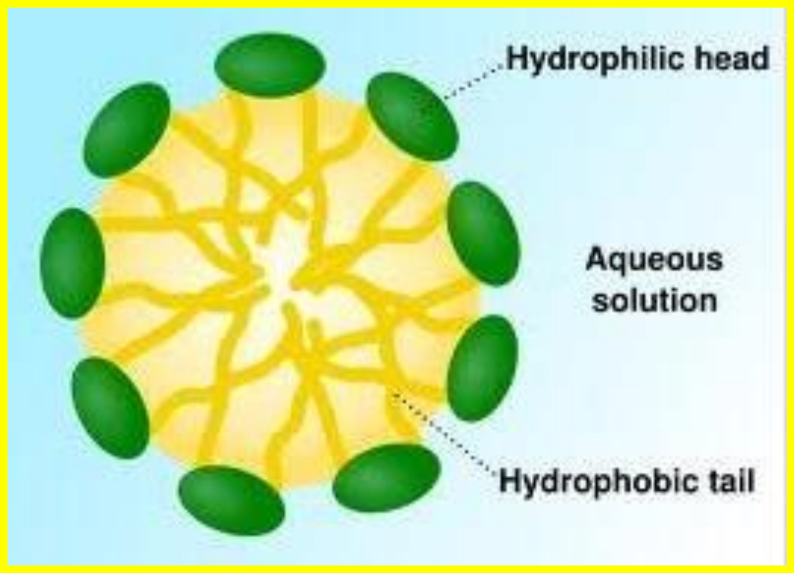
When phospholipids are placed in water, hydrophilic phosphate heads turn towards the water and the hydrophobic lipid tails turn away from the water, creating a double layered membrane that surrounds the cell.



How Soaps Work

Soap is very similar to a phospholipid in that it also has a polar head and nonpolar tail.

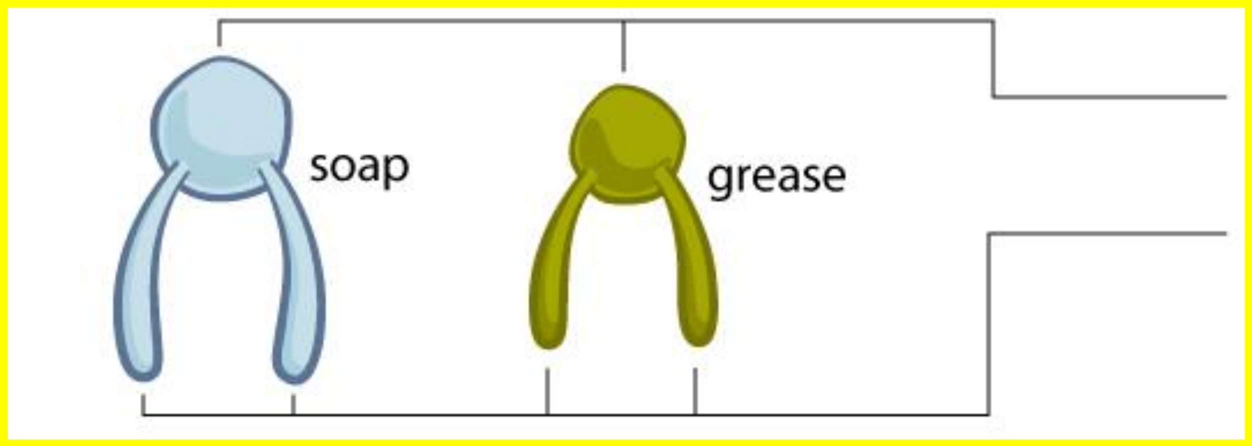




When soap encounters water the nonpolar hydrophobic tails turn away from the water and the polar hydrophilic heads turn towards the water, forming a soap bubble.

How Soaps Work

Grease, being a lipid, also contains a polar hydrophilic head and a nonpolar hydrophobic tail, very similar to soap.

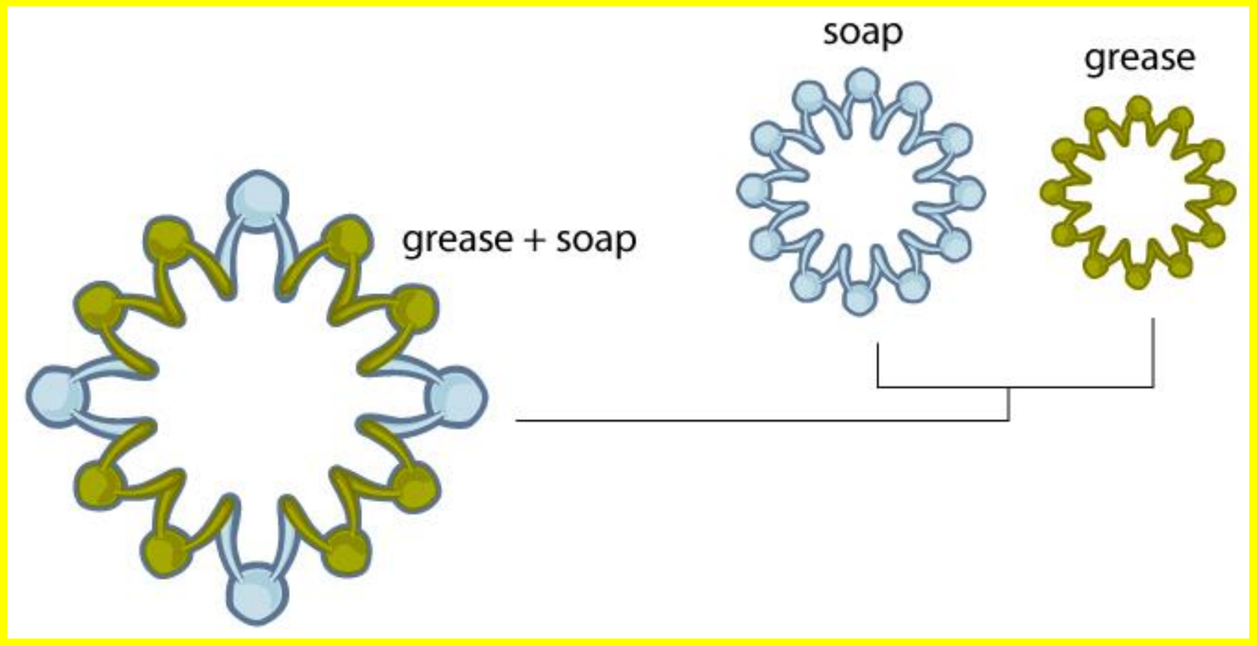


Hydrophilic Polar Heads

Hydrophobic Nonpolar Tails

How Soaps Work

Because grease and soap are so similar, when placed in water, the two combine to form one bubble which can then be washed away.

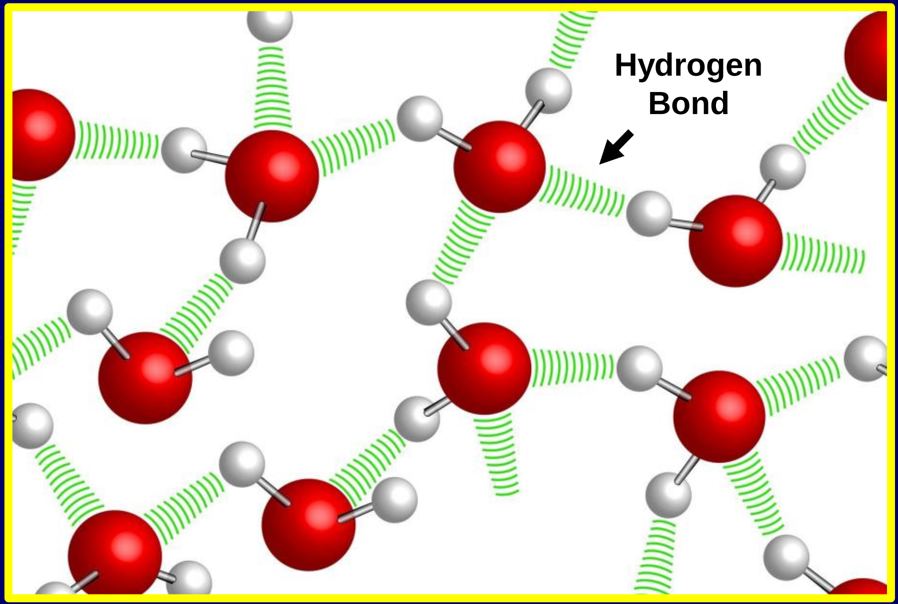


Adhesion

The polar nature of water also allows water molecules to stick to other polar substances, a property known as adhesion.

Cohesion

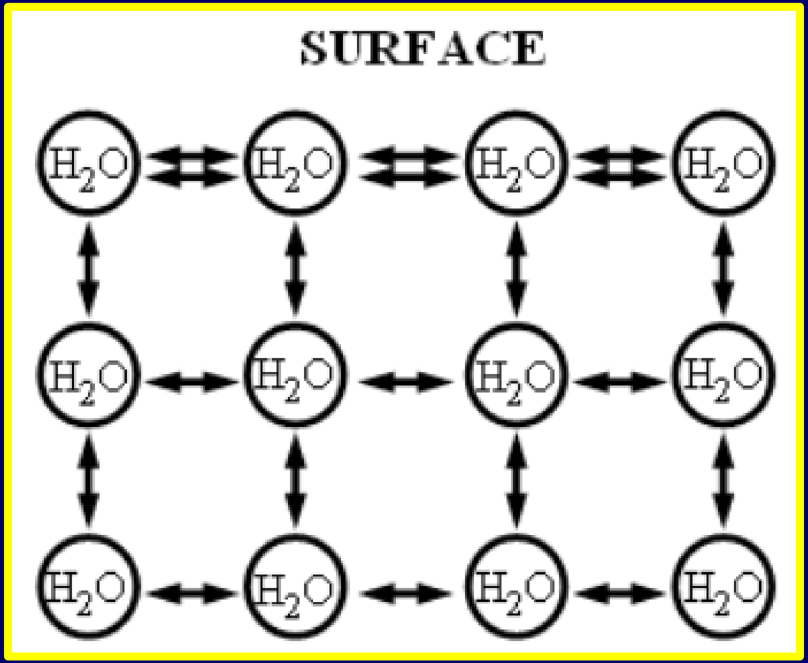
The weak hydrogen bonds between water molecules is responsible for water's cohesive properties, such as spherical drops.



Cohesion – water sticking to water

Surface Tension

Water molecules want to cling to each other. However, at the surface, there are fewer water molecules to cling to, since there is air above.



As a result, water molecules at the surface form stronger bonds with each other, creating a barrier at the surface known as surface tension.

Water Striders

The long legs of water striders, which allows them to evenly distribute their weight over a large surface area, combined with the surface tension of water, enable them to walk on water.

Meniscus

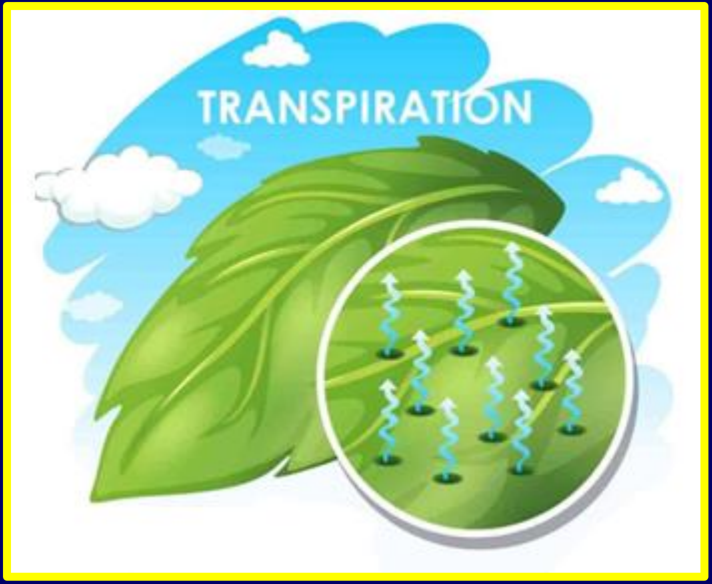
Adhesion causes water molecules to be attracted to the molecules in the wall of the glass beaker and will cause them to travel up the glass as far as gravity will allow.

Cohesion causes the other water molecules to stick to the water molecules that are adhered to the surface of the glass.

Surface tension creates the visible meniscus.

Capillary Action

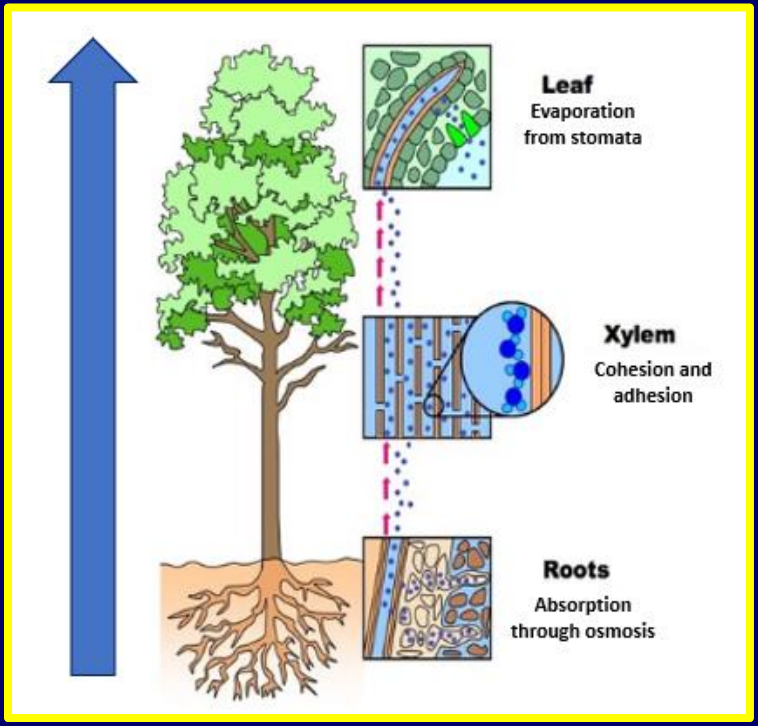
On the underside of leaves are small openings, called stomata, that allow oxygen and carbon dioxide gas to pass through.



However, on hot days, water also evaporates out through the stoma in a process called transpiration.

Capillary Action

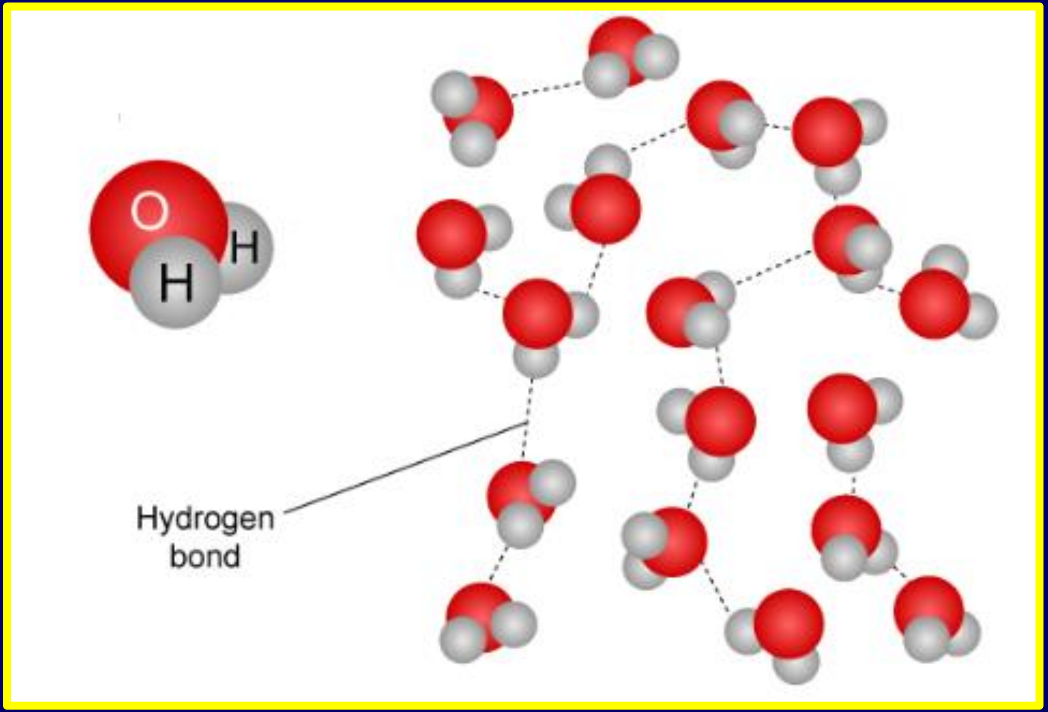
As water molecules evaporate out of the stomata, the cohesive and adhesive properties of water, allow more water molecules to be pulled upward, within the xylem tubes in the stems of plants.



The movement of water up a thin tube, due to cohesion and adhesion, is called capillary action.

High Heat Capacity

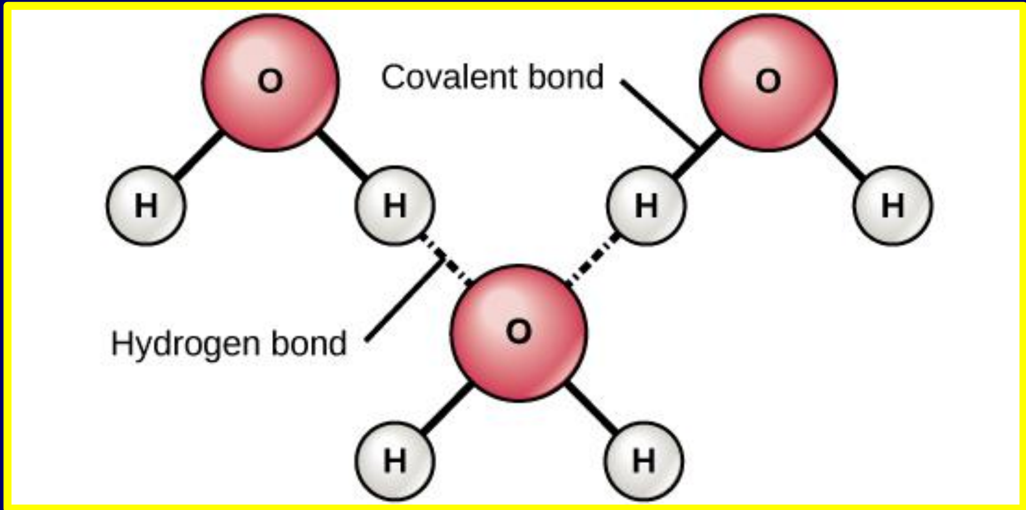
The hydrogen bonds between water molecules also allow water to absorb a lot of heat before increasing in temperature.



The ability of a material to absorb heat is called heat capacity.

Chemical Bonds

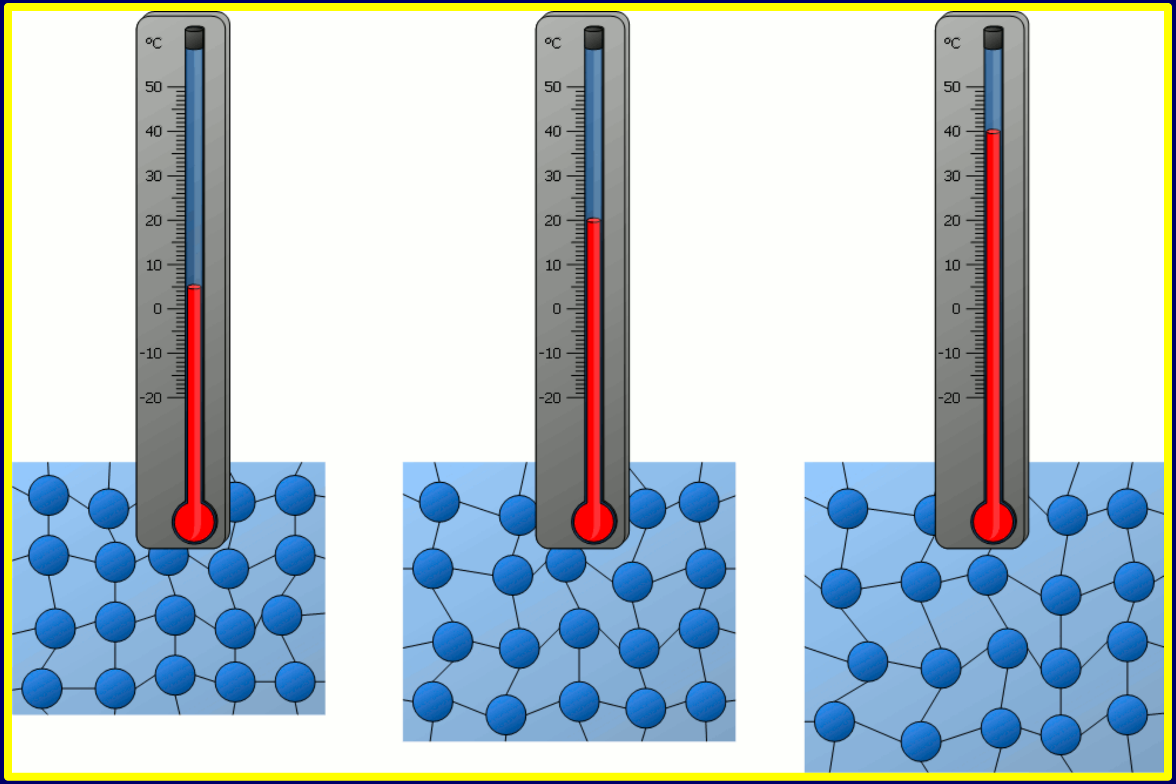
The covalent bonds that form the water molecule are very strong and can only be broken by chemical reactions.



However, the hydrogen bonds between different water molecules are weak and can be broken with the addition of heat.

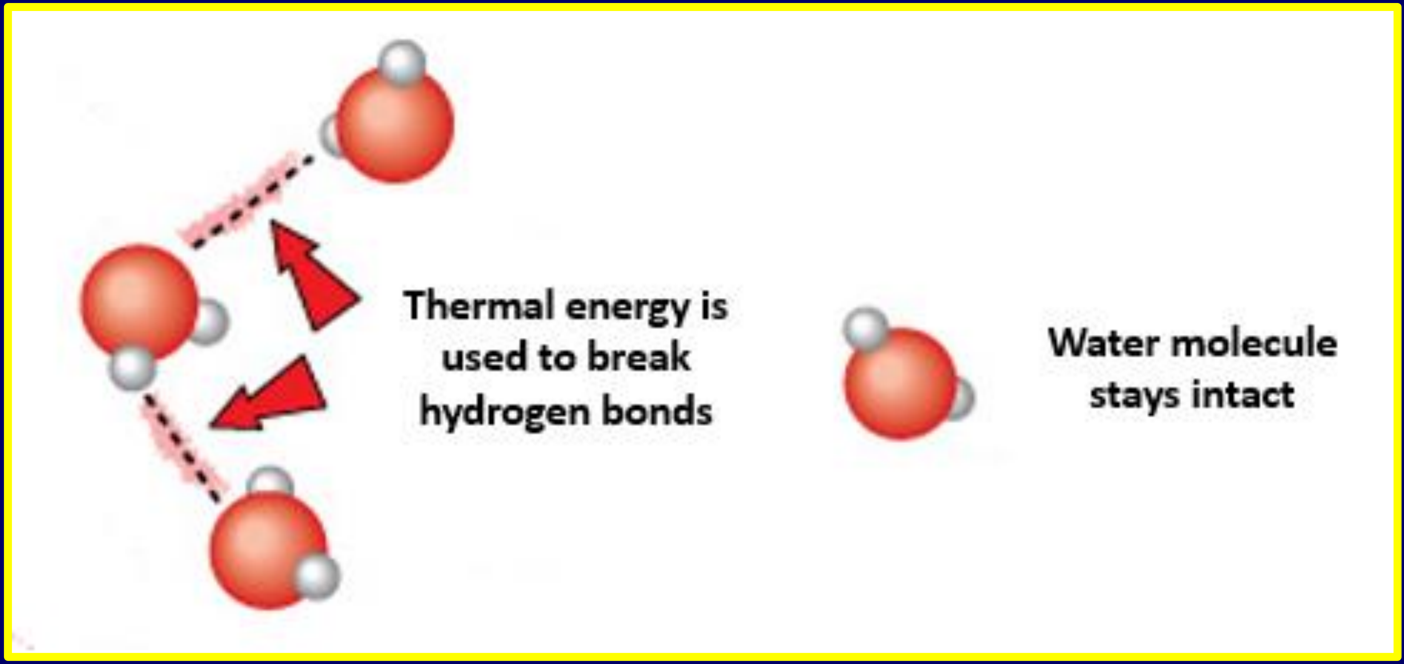
Addition of Heat

When heat is added to a substance, the molecules begin vibrating faster and increase in temperature.



High Heat Capacity

However, when heat is added to water, most of the energy is used to break the hydrogen bonds, before the water molecules can begin to vibrate and increase in temperature.

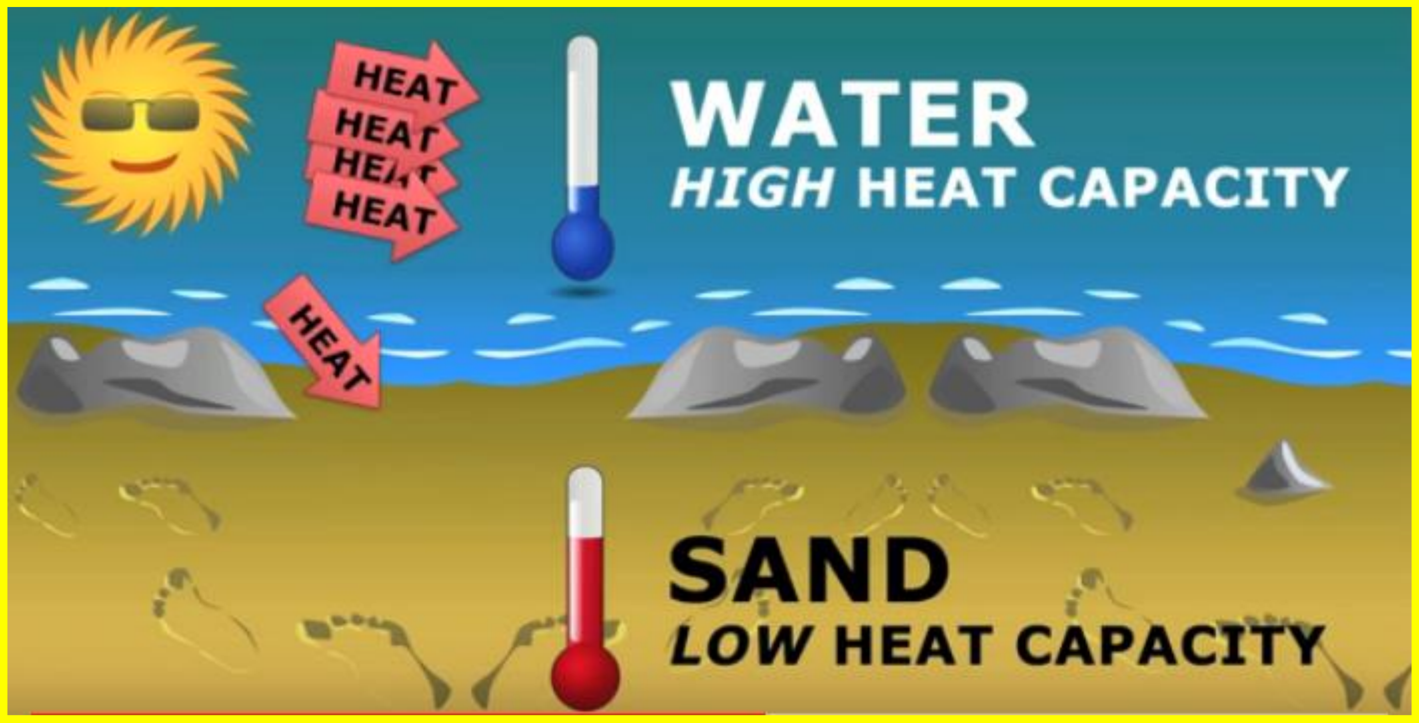


Different Heat Capacities

At the beach, both the water and the sand receive the same amount of sunlight, but they increase in temperature at different rates due to different heat capacities.

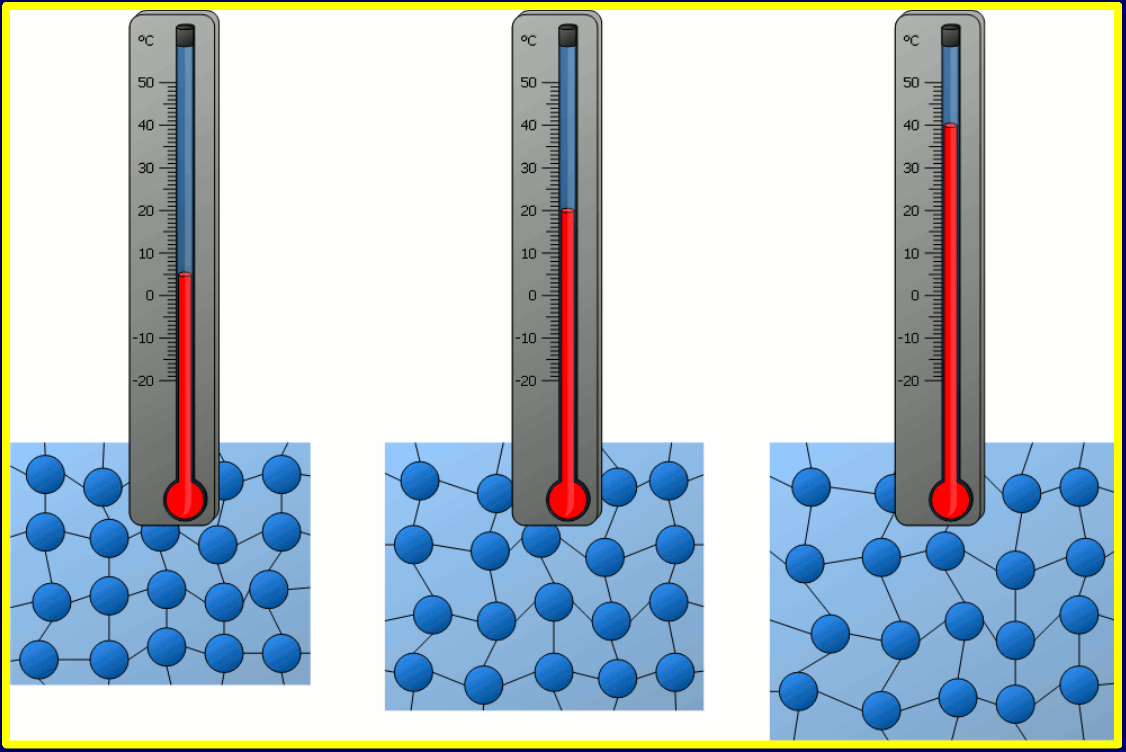
Different Heat Capacities

The high heat capacity of water allow it to remain cool, while the low heat capacity of the sand cause it to become hot.



Less Dense as a Solid

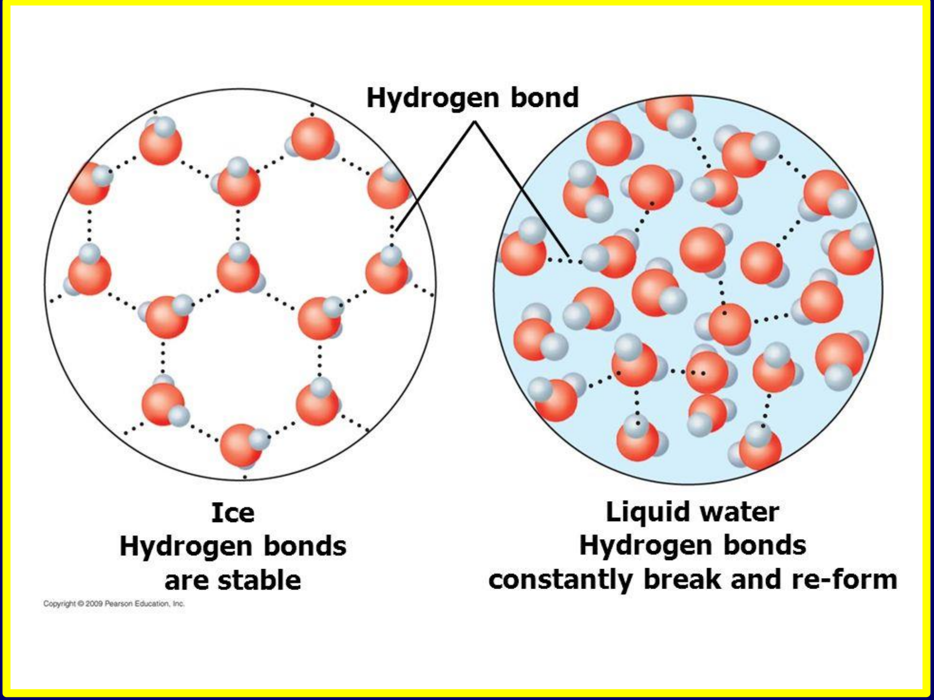
The hydrogen bonds between water molecules also allow water to be less dense when it is a solid than when it is a liquid.



As water loses heat and cools down, the vibrations of the water molecules slow down.

Less Dense as a Solid

The slowing down of the water molecules allows the hydrogen bonds to stabilize and hold the water molecules apart.



As a result, ice is less dense than liquid water and will float on water.

Ice Floats

In lakes and ponds, as the water freezes, it forms an ice barrier on top of the water, protecting the water underneath from becoming any colder.

The End