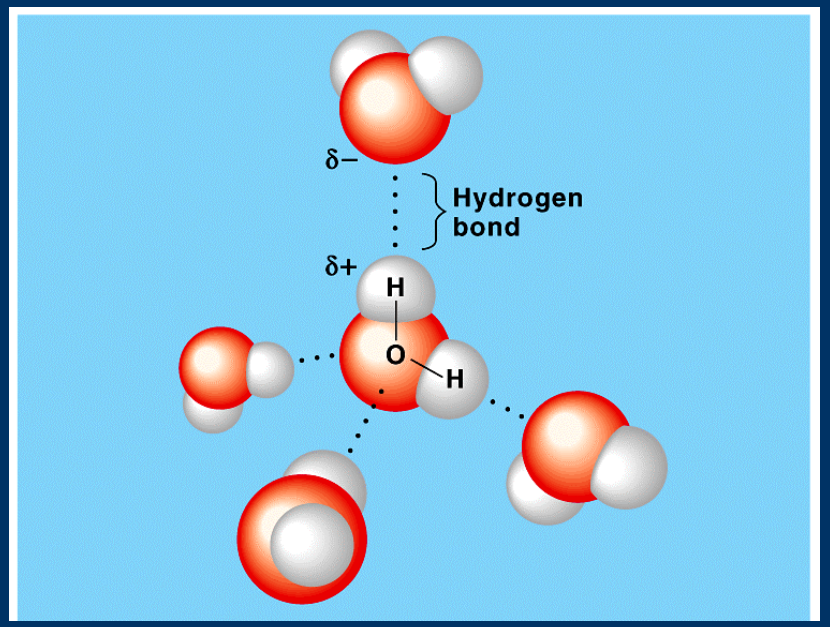
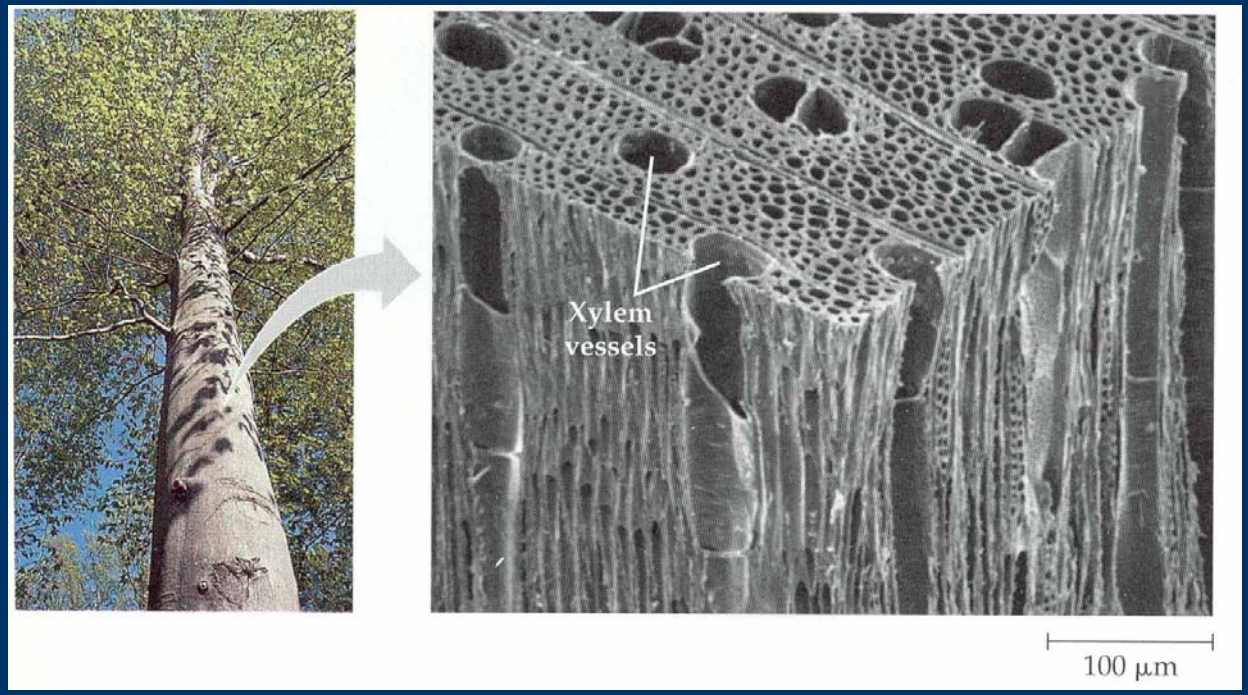
Water and the Fitness of the Environment

A water molecule can form hydrogen bond with 4 neighbor molecules of water:

-polar molecule
-cohesive molecule



-high surface tension -good solvent
-high specific heat and heat of vaporization
-density of ice is lower than density of liquid



The hydrogen bonds hold water molecule together = cohesion.

Adhesion = clinging of one substance to another (e.g.adhesion of the water to the vessel wall)

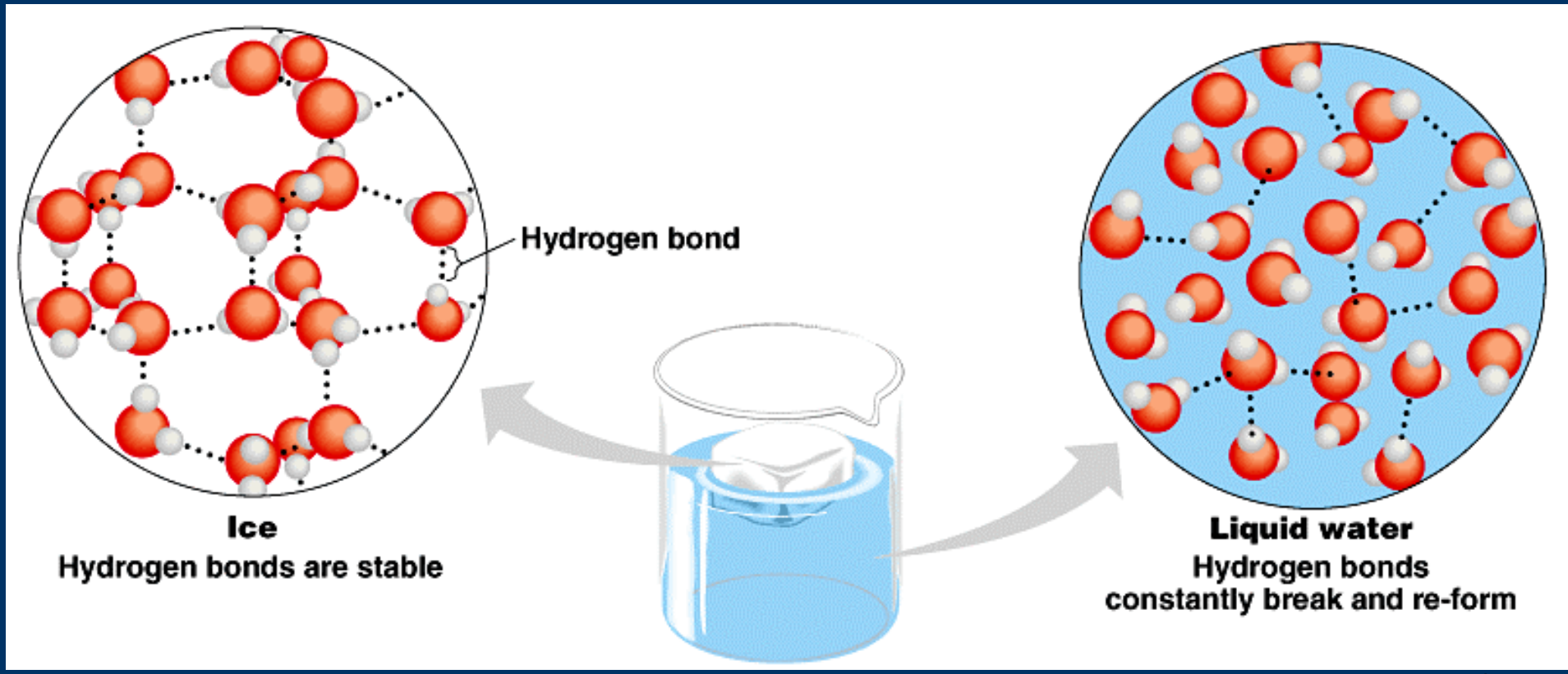
Cohesion and adhesion contribute to the transport of water against gravity in plants.

Surface tension

Water has high surface tension due to the ordered arrangement of water molecule.

This property of water allow the water strider to walk on a pond without breaking the surface.

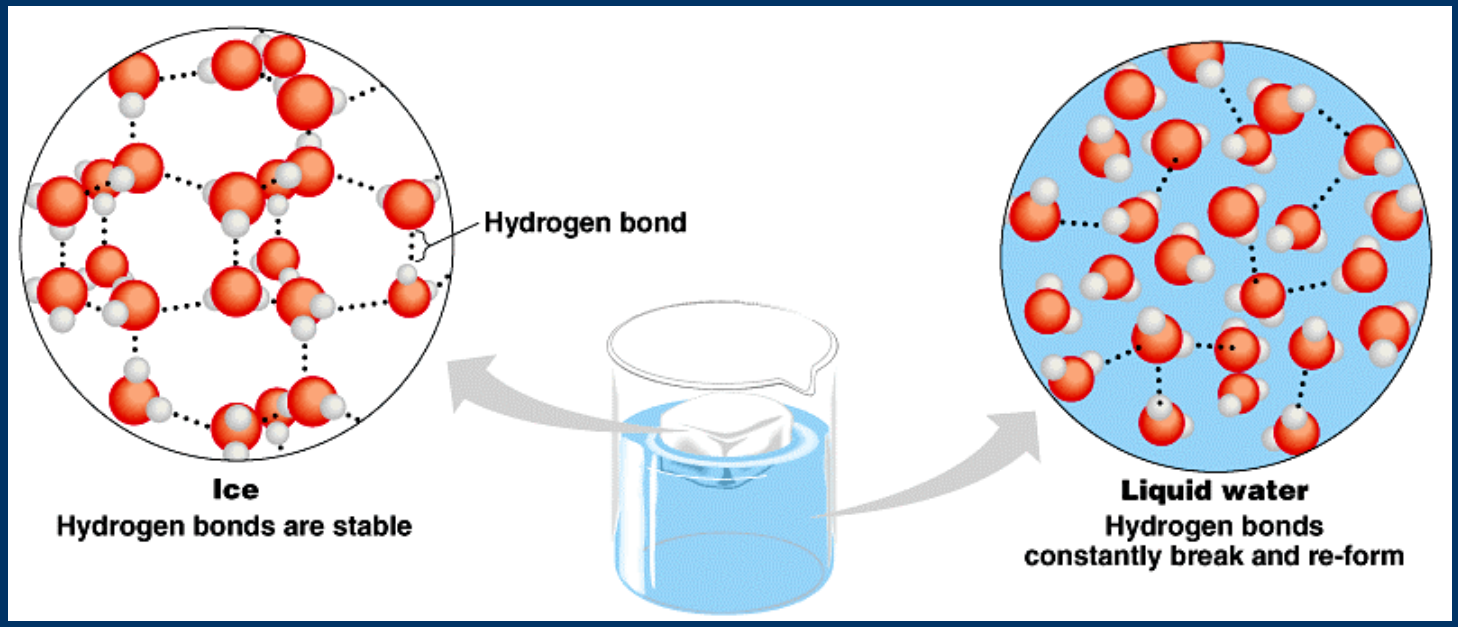
In ice, water molecules are spacious. Each water molecule is hydrogen bonded to the maximum of 4 neighbors in 3-dimensional crystal.



As temperature rises, the hydrogen bonds between molecules are disrupted and free to slip closer together .

At 4^{o} C, water has the greatest density.

In liquid water, the hydrogen bonds are constantly breaking and re-forming.



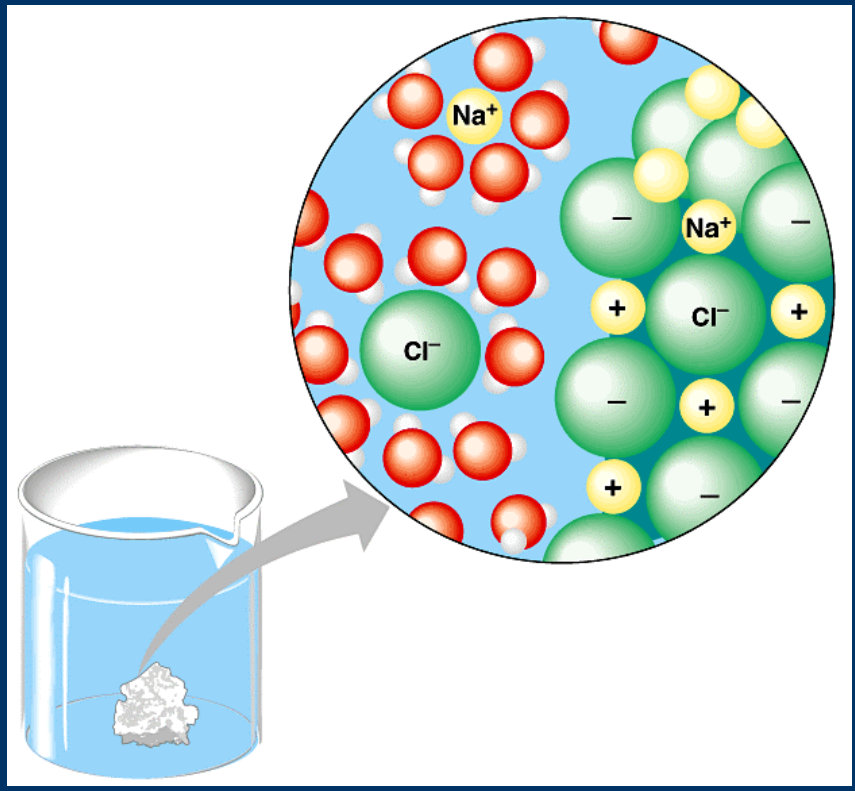
Since ice is less dense than water, the floating ice insulates the liquid water below, preventing it from freezing and allowing life to exist under the frozen surface.

The krill beneath the antarctic ice.

Water: the Solvent of Life

The polar property of water renders it to be a good solvent.

e.g. a crystal of table salt dissolving in water.

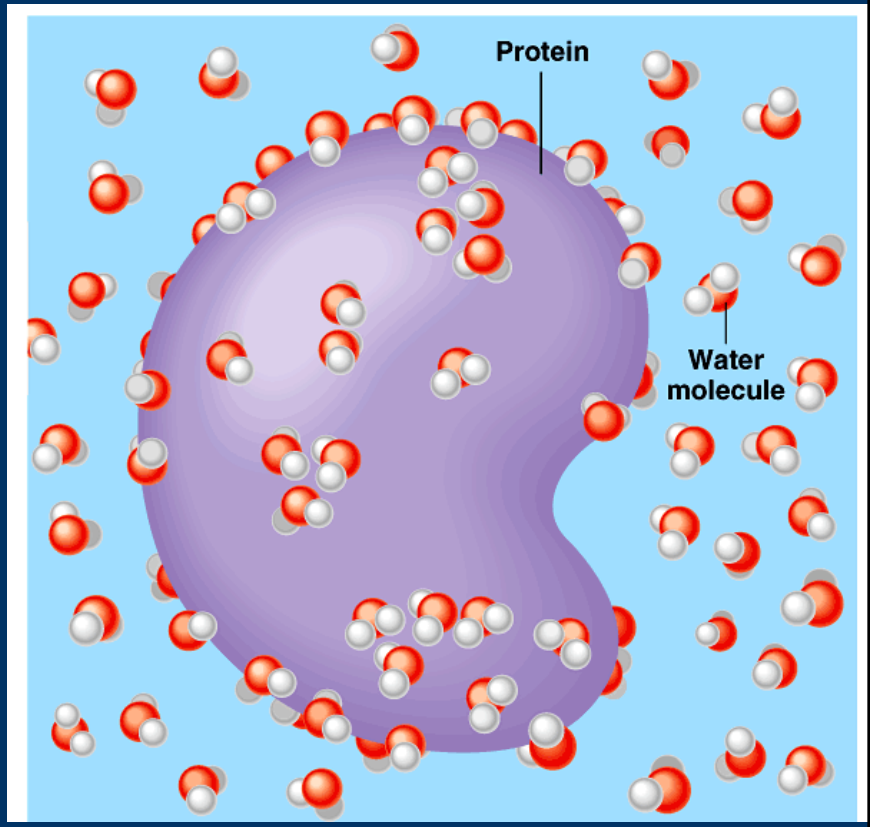


The negative oxygen regions of polar water molecules are attracted to sodium cations (Na^+).

The positive hydrogen regions of water molecules are attracted to chloride anions (Cl^-).

A water soluble protein:

Molecule as large as protein can be dissolved in water if it has enough ionic and polar regions on its surface.



Hydrophilic and Hydrophobic Substances

Hydrophilic: *hydro* = water
phylos = love

-substances that have affinity for water

-does not need to be dissolved
-ionic or polar molecule

e.g. cotton which can absorb water but too large to be dissolved in water.

Hydrophobic: *hydro* = water

phobos = fear

-substances that do not have affinity to water or repel water

-nonpolar or non-ionic molecule

e.g. cooking oil, cell membrane

Water Modulates Temperature on Earth

-Water is an effective heat bank.

-It can absorb or release a large amount of heat with only a slight change in its own temperature.

-Water stabilizes air temperature by absorbing heat from air that is warmer and releasing the stored heat to air that is cooler.

Specific Heat (ความร้อนจำเพาะ)

Specific heat of a substance is the amount of heat that must be absorbed or lost for 1 g of that substance to change its temperature by 1^0C.

Specific heat of water = 1 calorie per gram per degree Celsius

Specific heat of ethanol = 0.6cal/g/^{0}C

Water has high specific heat in comparison to other materials due to hydrogen bonding.

Thus, temperature of water will change less when it absorbs or loses a given amount of heat.

Water absorbs heat from the sun during the daytime and summer while warming up a few degree.

At night and during winter, the gradually cooling water can warm the air.

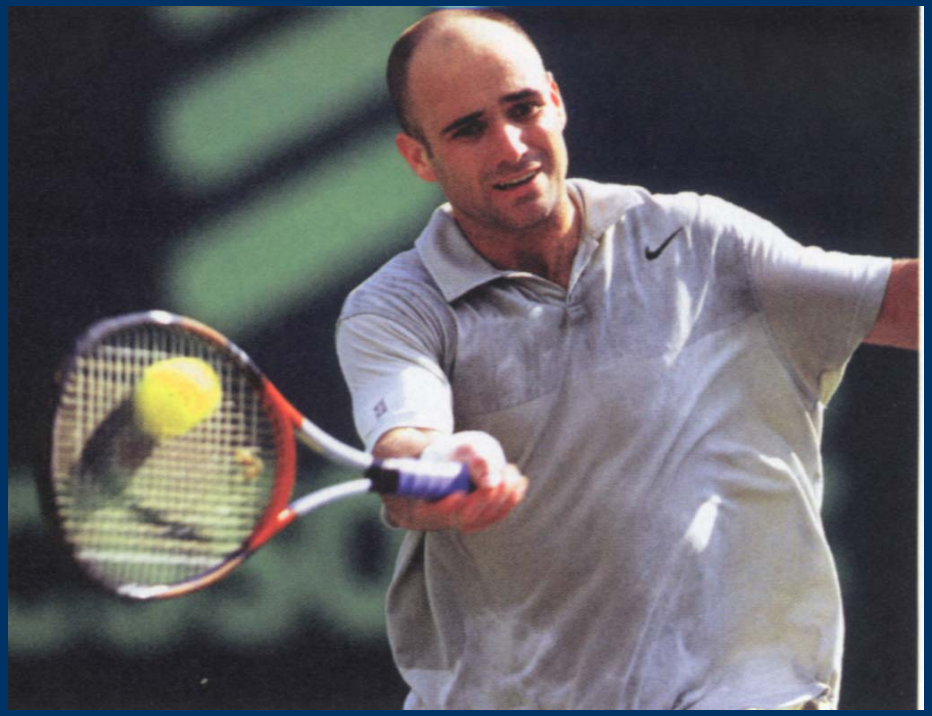
Heat of Evaporation (ความดันไอ)

= the quantity of heat a liquid must absorb for 1 g of it to be converted from the liquid to the gaseous state.

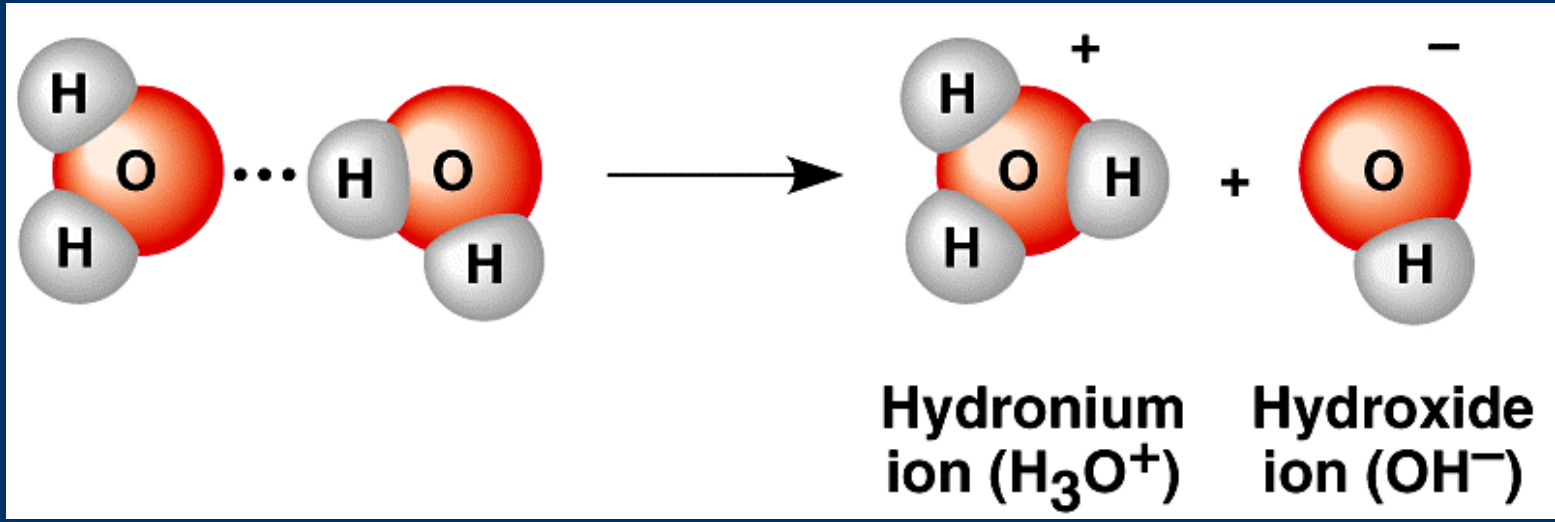
Water has high heat of evaporation compare with other liquids : 580 cal of heat is needed to evaporate 1 gram of water at room temperature.

Water's high heat of evaporation help moderate earth climate.

Evaporation of sweat from human skin dissipates body heat and helps prevent overheating on a hot day or when excess heat is generated by strenuous activity.



The Dissociation of Water Molecules



Occasionally, a hydrogen atom shared by 2 water molecules in a hydrogen bond shifts from one molecule to the others = transfer of a hydrogen ion as a single proton with a charge of +1.

In pure water, the concentration of H^+ and OH^- = 10^{-7} M at 25^oC

Dissociation of water is reversible.

Acid Base and pH

Acid = a compound that donates protons or increases hydrogen ion concentration [H^+] in solution.

Base = a compound that accepts protons or reduces hydrogen ion concentration [H^+] in solution.

Strong and weak acid depends on the extent to which they ionize.

Strong acid or base = compound that is totally ionized

Weak acid or base = compound that is partially ionized

The pH Scale

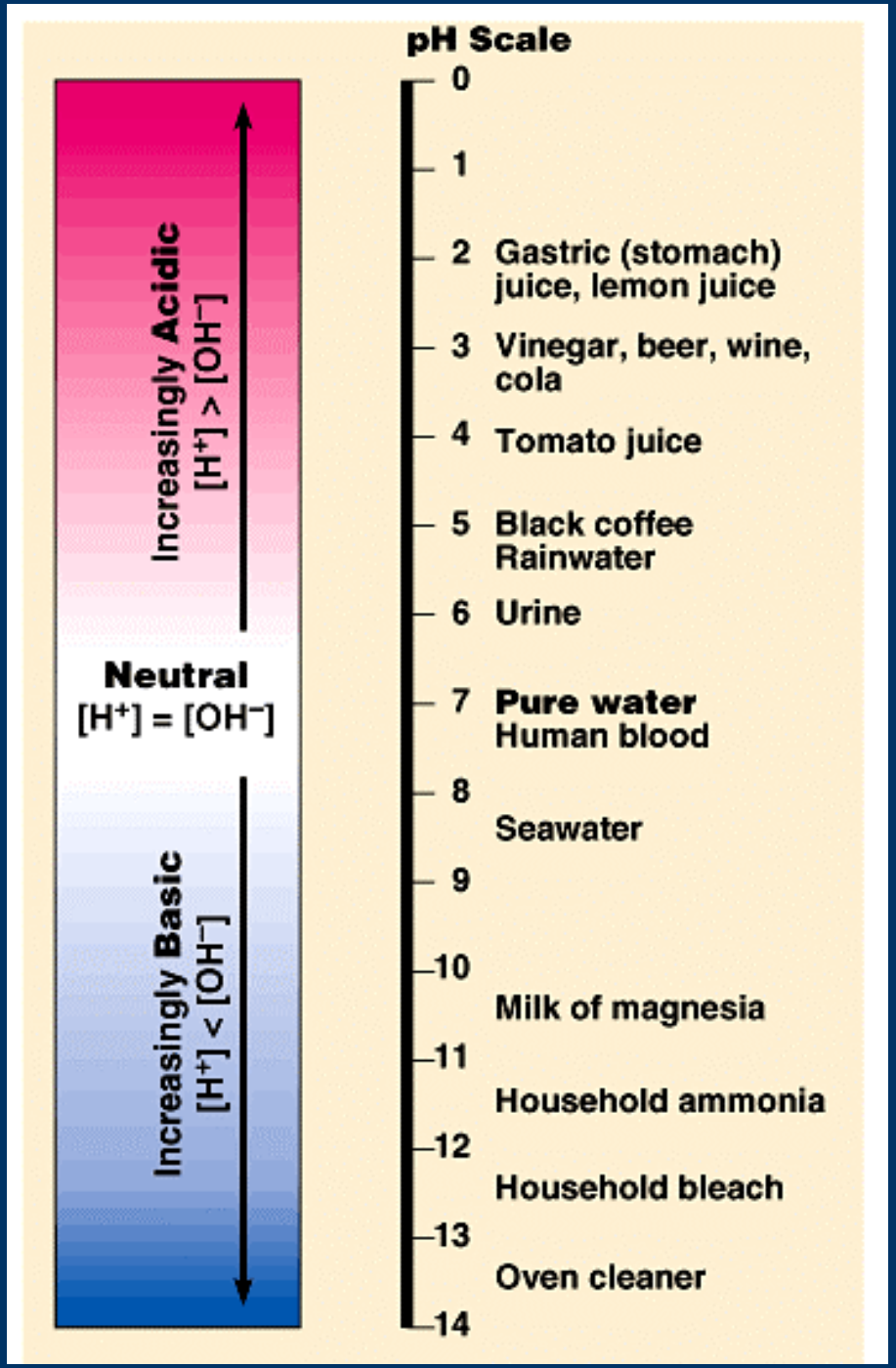
$[H^+][OH^-] = 10^{-14}$

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

Neutral solution pH = 7

Acid pH < 7

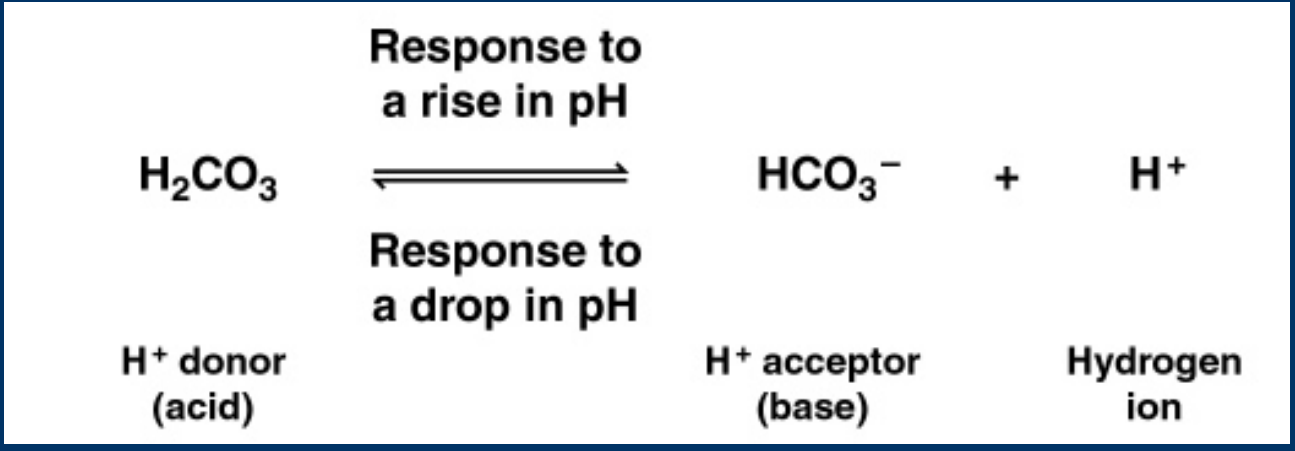
Base pH > 7



Buffers

= substance that minimize changes in the concentration of H^+ and OH^- in a solution

-contain a weak acid and its corresponding base



Carbonic acid contributes to pH stability in human blood