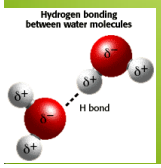
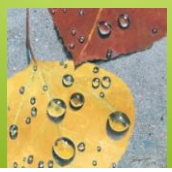
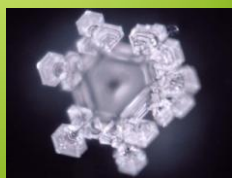


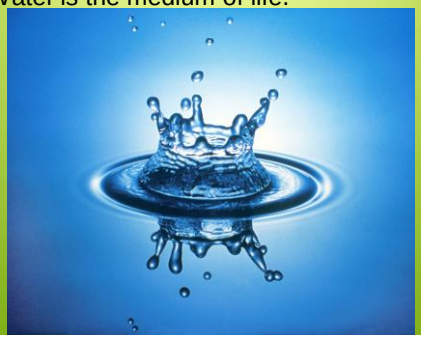

Molecular Biology 2.2- Water



Essential idea:

- Water is the medium of life.



Nature of Science:

- Use theories to explain natural phenomena
  - the theory that hydrogen bonds form between water molecules, explains the properties of water. (2.2)

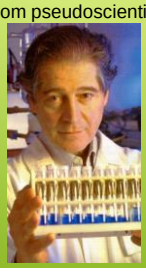
International-mindedness:

- What are the challenges for the increasing human population in sharing water resources equitably for drinking, irrigation, electricity generation and a range of industrial and domestic processes?



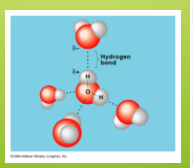

Theory of knowledge:

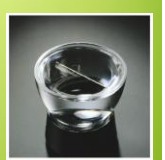
- Claims about the "memory of water" have been categorized as pseudoscientific.
- What are the criteria that can be used to distinguish scientific claims from pseudoscientific claims?



Cohesion of Water

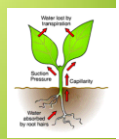
- 4 Hydrogen bonds hold water molecules together
- Creates Surface tension
  - Measurement of the difficulty to break or stretch the surface of a liquid
  - Must break the H-bonds to break the tension



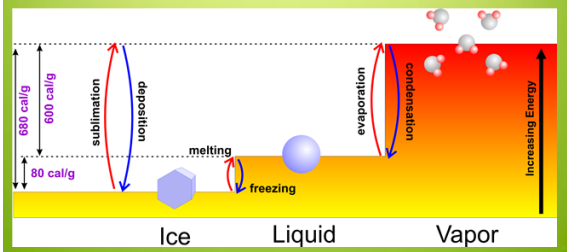

Adhesion of Water

- H- bonds hold water molecules to another substance
- Adhesion to solid surfaces creates capillarity
- Capillarity allows water to move against gravity
- Plants can grow tall



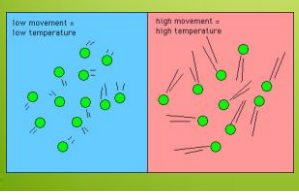
Thermal Properties of Water

- Due to latent periods of phase changes
- Comparison to methane



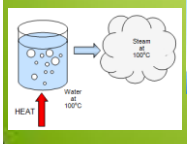
High Specific Heat of Water

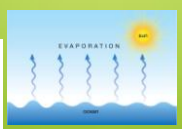
- Amount of heat absorbed or lost to change temperature by 1°C
- Water's high specific heat is due to H-bonds
- Keeps temperatures constant

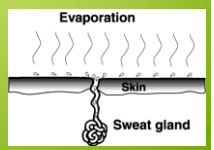


High Heat of Vaporization of Water

- Quantity of heat required to convert 1g from liquid to gas states
- Creates evaporative cooling
  - Temp of surrounding drops
  - Prevents overheating
  - Regulates temp in standing bodies of water





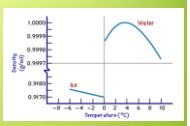


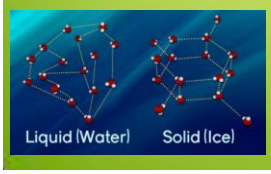
High Heat of Fusion of Water

- Quantity of heat required to convert unit mass of a liquid into a solid
- Temp of surrounding rises

Density of Water

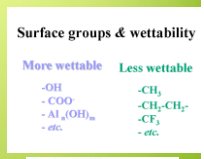
- Less dense as solid than liquid
- Due to hydrogen bonding
- Crystalline lattice keeps molecules at a distance
- Water is most dense at 4°C= ice floats
- Keeps free water on earth

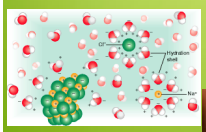


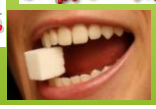


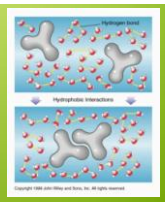
Solvency of Water

- Versatile Solvent
- Breaks up ionic compounds
- Dissolves other polar molecules
- Creates hydrophylic and hydrophobic interactions with different molecules



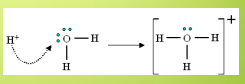


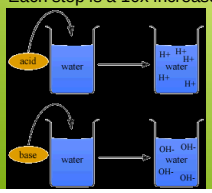


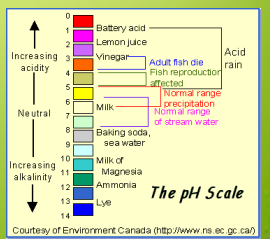


Acid/Base & PH

- Water dissociates into a hydrogen ion (hydronium ion) and a hydroxide ion
- Acids release H^+ ions
- Bases release OH^- ions
- pH Scale
  - "power/percent of hydrogen"
  - measures H^+ concentration
  - Each step is a 10x increase



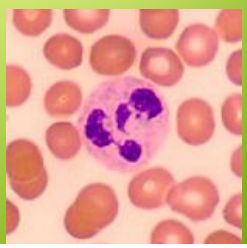




Buffers

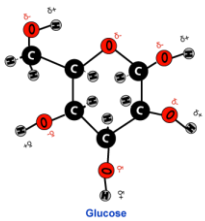
- Substances that accepts or donates H^+ ions
- Minimize change in pH
- Acid Rain
  - Causes deforestation by changing soil pH
  - Destroys life in water

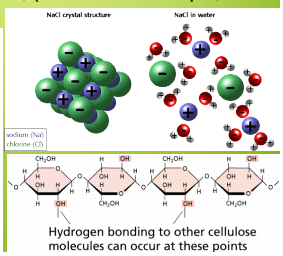

Acid-rain damage, Slamba Poremba, Poland
Credit: C. Martin, The Environmental Picture Library



Hydrophilic Substance

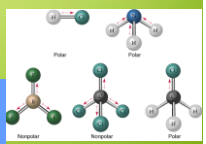
- Substances that dissolve in water
  - Polar molecules (glucose)
  - Particles with positive or negative charges (sodium and chloride ions)
- Substances that water adheres to, (cellulose for example, are also hydrophilic)





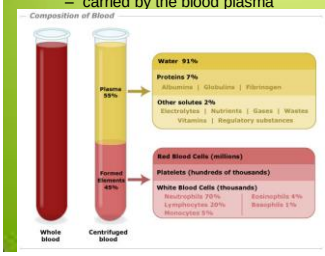
Hydrophobic Substances

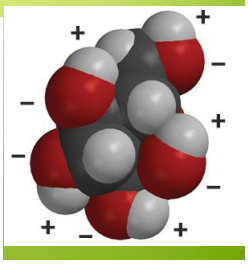
- Insoluble in Water
- Do not have negative or positive charges and are nonpolar
- All lipids are hydrophobic, including fats and oils
- Hydrophobic molecules dissolve in other solvents such as propanone (acetone)



Mode of Transport

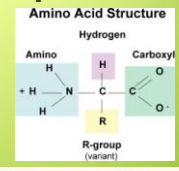
- Blood plasma consists of mainly of water (95%) plus dissolved substances which it transports
- Glucose
  - polar molecule hence freely soluble
  - carried by the blood plasma

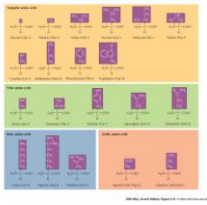




Mode of Transport

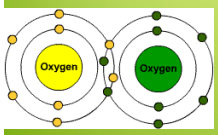
- Amino Acids
  - Positive and negative charges (due to the amine and acid groups)
  - therefore soluble in water
  - carried by the blood plasma
  - R group varies
    - polar
    - non-polar
    - charged
  - R group determines the degree of solubility

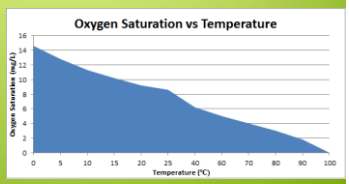




Mode of Transport

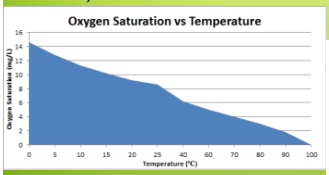
- Oxygen
  - Non-polar molecule
  - Due to the small size of an oxygen molecule it is slightly soluble in water
  - Water becomes saturated with oxygen at relatively low concentrations
  - As temperature increases the solubility of oxygen decreases

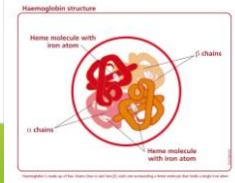




Mode of Transport

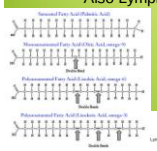
- Oxygen
  - At body temperature (37 °C) very little oxygen can be carried by the plasma (too little to support aerobic respiration)
  - Hemoglobin in red blood cells carry the majority of oxygen (4 binding sites)

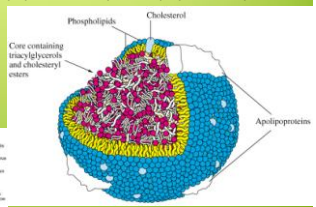




Mode of Transport

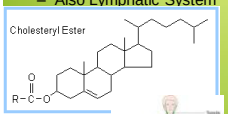
- Fats
  - Large, non-polar molecules
  - Insoluble in water
  - Carried in plasma inside lipoprotein complexes (chylomicron)
  - Also Lymphatic system





Mode of Transport

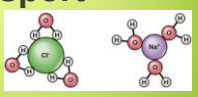
- Cholesterol
  - Hydrophobic
    - Small hydrophilic region at one end
    - Not enough to make cholesterol dissolve in water
  - Carried in blood plasma in lipoprotein complexes (chylomicrons)
  - Also Lymphatic System

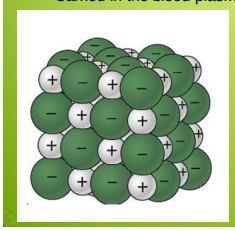


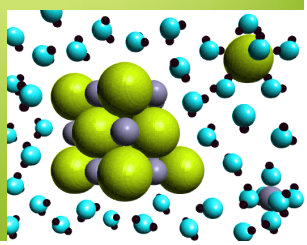
Mode of Transport

- Sodium Chloride
  - Ionic compound
  - Freely soluble in water
  - Dissolving to form sodium ions (Na+) and chloride ions (Cl-)
  - Carried in the blood plasma

End







Memory of Water

- Investigation of homeopathy by French scientist Jacques Benveniste
- Pure water could somehow remember what it had previously contained.
  - Started with a substance that caused an allergic reaction
  - Diluted it over and over again until there was nothing left except water
  - Observed that the pure water still managed to trigger an allergic reaction when it was added to living cells.
- Published in "Nature" in 1988.
- Investigation team of editor John Maddox, chemist Walter Stewart and James Randi, a magician, debunked claim.

BBC Article
http://news.bbc.co.uk/2/hi/health/7505286.stm

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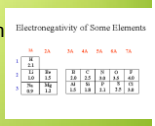
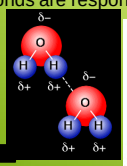
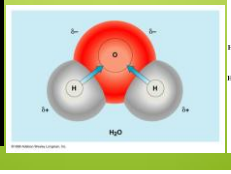
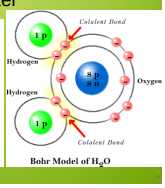
Polarity and H-Bonds

- Water molecules are polar and hydrogen bonds form between them
- Oxygen is more electronegative than hydrogen
- Electrons spend more time closer to Oxygen
- Uneven charge on molecule makes it polar.
- Polarity creates hydrogen bonds
- H-bonds are responsible for properties of water









Bohr Model of H_2O

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Comparison of Thermal Properties to Methane

- The significance of hydrogen bonding in water.

2.2.A1 Comparison of the thermal properties of water with those of methane.

	Methane	Water
		
Formula	CH_4	H_2O
Molecular mass	16	18
Bonding	Single covalent	
Polarity	nonpolar	polar
Density (g cm^{-3})	0.46	1
Specific Heat Capacity ($J g^{-1} °C^{-1}$)	2.2	4.2
Latent heat of vapourisation ($J g^{-1}$)	760	2257
Melting point (°C)	-182	0
Boiling point (°C)	-160	100

Methane
- waste product of anaerobic respiration in certain prokaryotes living in anaerobic conditions
- Methane can be used as a fuel
- If present in the atmosphere it contributes to the greenhouse effect.

Key chemical property that causes the major differences seen in the physical properties.

Methanogenic prokaryotes
- can be found in swamps, wetlands, the guts of animals (including cattle and sheep)
- can also be found in waste dumps

https://commons.wikimedia.org/wiki/Water_molecule#/media/File:Water_molecule.svg
https://upload.wikimedia.org/wikipedia/commons/3/3b/Methane.PNG

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