Mohammads notes.

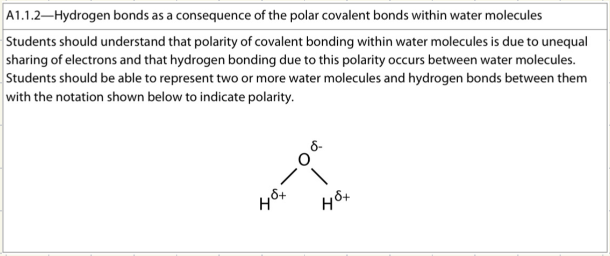
Topic 1.1: water

A1.1.1 - water as a medium of life

A1.1.1—Water as the medium for life
Students should appreciate that the first cells originated in water and that water remains the medium in which most processes of life occur.

- The first cells evolved in a watery environment
- This is believed to have been in the deep oceans.
- Some water and solutes got trapped within a membrane
- Chemical reactions began occurring within the membrane-bound structure
- This led to the evolution of cells
- Water in its liquid state allows dissolved molecules to move around, so they are easily able to collide and react with each other
- Most life processes occur in water
- The link between water and life is so strong that scientists looking for life on other planets and moons look for evidence of water to suggest that life could have occurred there

A1.1.2 - hydrogen bonds as a consequence of the polar covalent bonds within water molecules



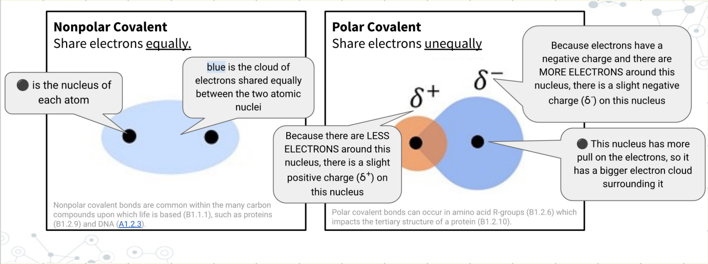
A1.1.2—Hydrogen bonds as a consequence of the polar covalent bonds within water molecules

Students should understand that polarity of covalent bonding within water molecules is due to unequal sharing of electrons and that hydrogen bonding due to this polarity occurs between water molecules. Students should be able to represent two or more water molecules and hydrogen bonds between them with the notation shown below to indicate polarity.

The types of bonds:

- non-polar covalent bond
- polar covalent bond
- ionic bond
- hydrogen bond (intermolecular)

Covalent bond:



Ionic bond:

An ionic bond is an attraction between a positively charged ion and a negatively charged ion

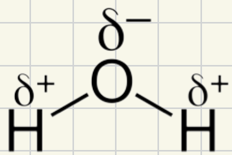
Hydrogen bond:

A hydrogen bond is an attraction between two polar molecules. A polar molecule is a molecule in which one end of the molecule is slightly positive and the other end is slightly negative.

The attraction between the partially positive and the slightly negative regions of two different polar molecules is called a hydrogen bond.

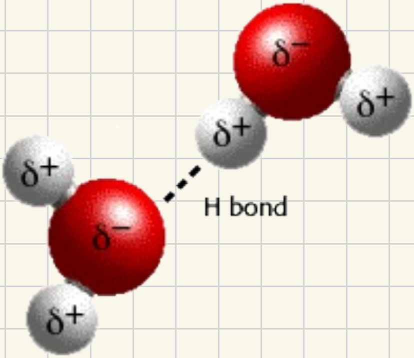
Water molecule:

Within a water molecule, electrons are shared through polar covalent bonding between the atoms. It's polar because of the unequal sharing of electrons. Since the nucleus of oxygen is more attractive to electrons than the nucleus of a hydrogen atom.



As mentioned before, A hydrogen bond is the force that forms when a partially positive hydrogen atom in one polar molecule is attracted to a partially negative atom of another polar molecule

Although a hydrogen bond is a weak intermolecular force, there are many of them per unit volume of water giving water unique properties.



A1.1.3 - cohesion of water molecules due to hydrogen bonding

A1.1.3—Cohesion of water molecules due to hydrogen bonding and consequences for organisms
Include transport of water under tension in xylem and the use of water surfaces as habitats due to the effect known as surface tension.

(exergonic)

All catabolic reactions release energy when breaking bonds

All anabolic reactions require energy when making bonds

(endergonic)

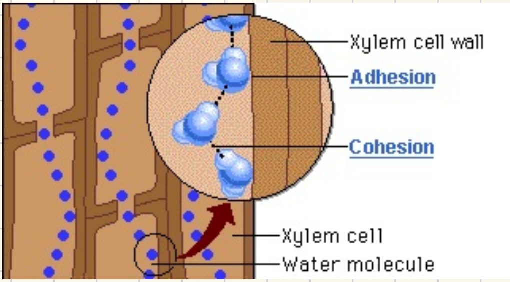
Waters ability to make hydrogen bonds with itself causes water molecules to stick together: cohesion.

Examples:
- allows plants to more under tension in xylem.
- retains water on earths surfaces to serve as habitats.
- contributes to the physical properties of water.

Conduction of water under tension in xylem:

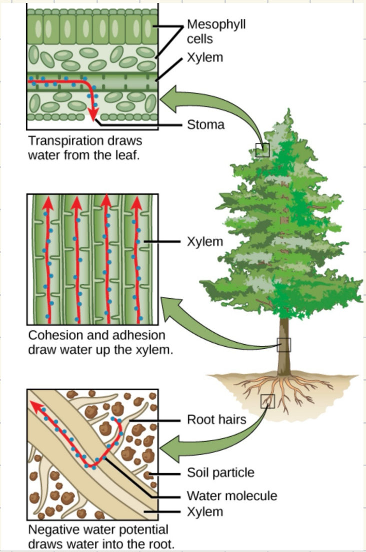
Cohesion allows the transport of water under tension in plants.

The xylem is a vascular tissue that transports water throughout a plant's body.



Transport of water under tension in xylem:

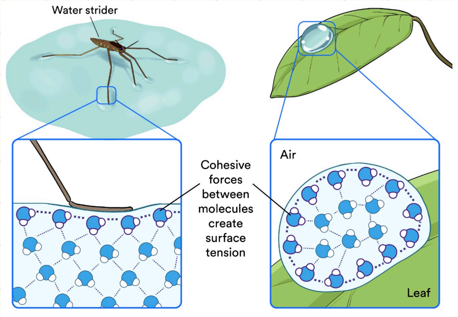
The cohesion-tension hypothesis is the most widely-accepted model for how water moves in vascular plants.:



1. Transpiration: Water evaporates from the leaves through open stomata, creating negative pressure (or tension).
2. Water Movement: This tension "pulls" water up through the plant's xylem, similar to how water is drawn up when you suck on a straw.
3. Cohesion: Water molecules stick together (cohesion) and form a continuous chain. As the top water molecules are pulled out of the stomata, they pull the rest of the water molecules up with them.
4. water molecules adhere to the walls of the xylem this helps to pull the water column upwards (1.1.4)

Water surfaces as habitats:

* Surface tension is a property of the surface of a liquid that allows it to resist an external force, due to the cohesive nature of its molecules. Water has a very high surface tension.



Water molecules are much more attracted to each other by hydrogen banding than to air particles causing water to act as if its surface is an elastic membrane in a body of water.

Cohesion between water molecules is greater than attractions between water and the floating object.

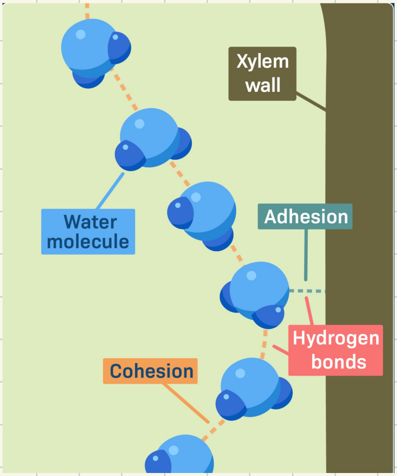
That's why it's possible to float objects on the surface of water. To break the surface of water, enough force must be applied to break many hydrogen bonds simultaneously.

A1.1.4 - adhesion of water to materials that are polar or charged

A1.1.4—Adhesion of water to materials that are polar or charged and impacts for organisms
Include capillary action in soil and in plant cell walls.

Hydrogen bonds can form between water and the surface of a solid composed of polar molecules. This causes water to stick to the surface of that solid and is called adhesion

It can also cause movement, as when water is drawn through narrow filled tubes. This is caused capillary action. The change from air-filled to water filled results in the release of energy because of the formation of hydrogen bonds *ask

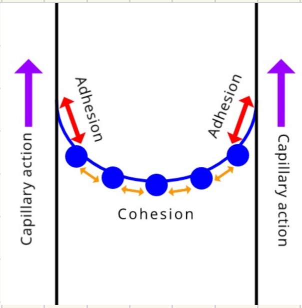


The adhesion of water molecules to other molecules:

- allows plants to move water using capillary action
- permits water to move through soil.

Impact of adhesion for organisms:

Capillary action is the movement of water in through a narrow space, often in opposition to external forces like gravity.



Plants can't thrive without capillary action. Capillary action helps bring water up into the roots.

Adhesion of water to the walls of a vessel will cause an upward force on the liquid at the edges and result in a concave meniscus.

Porous solids such is paper have large amounts of surface area attractive to water. Exerting strong suction forces such as adhesion.

Water is attracted to many chemical substances in soil. If soil is porous, water is drawn by capillary action through day soil, wetting it. This is how water can rise up.

Water adheres to cellulose molecules in cell wall, so any wall that dries out is automatically rewetted as long as there's water.

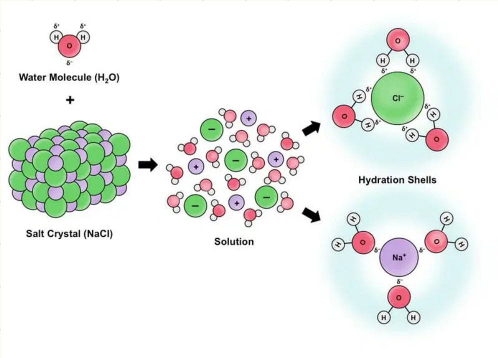
A1.1.5 - solvent properties of water

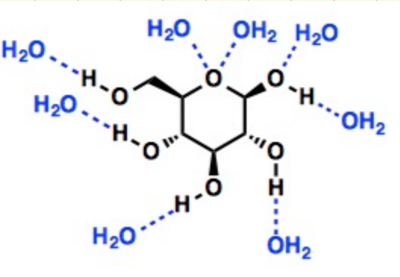
A1.1.5—Solvent properties of water linked to its role as a medium for metabolism and for transport in plants and animals
Emphasize that a wide variety of hydrophilic molecules dissolve in water and that most enzymes catalyse reactions in aqueous solution. Students should also understand that the functions of some molecules in cells depend on them being hydrophobic and insoluble.

When a solute dissolves in water, their molecules separate from each other and become surrounded by the water molecule. A solution is the mixture of a solute dissolved in a solvent.

The water forms hydrogen bonds with the solute forming a water/hydration shell around the solute.

Polar molecules will dissolve in water because they are hydrophilic, and can form hydrogen bonds with water.





The partially positive charge of the hydrogen atom in the water molecule is attracted to the negatively charged region of the solute.

The partially negative charge of the oxygen atom in the water molecule is attracted to the positive charged region of the solute.

Charged ions will also dissolve in water because they are hydrophilic

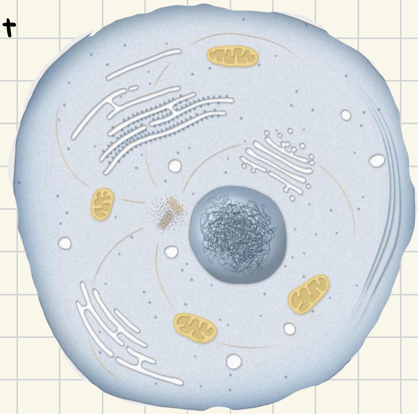
Water is not a universal solvent

Molecules that are non-polar or do not have a charge will not dissolve in water because they are hydrophobic. hydrophobic molecules can not attract water so they are insoluble. Hydrophobic molecules are attracted to other hydrophobic molecules, so they will clump together when exposed to water.

Hydrophobic substances can dissolve in other solvents such as propane. All lipids are hydrophobic, including fats and oils.

Waters solvent properties allows it to be a medium for metabolism

Cytosol is the liquid part of the cytoplasm. And it's composed of about 80 percent water and contains dissolved salts, fatty acids, sugars, amino acids, and proteins such as enzymes.



These dissolved substances are needed to carry out metabolic process required to keep the cell alive. If these molecules were not hydrophilic, they could not be able to preform their function.

Water is needed for cellular metabolism because it dissolves the reactants and enzymes so they can come together for reactions.

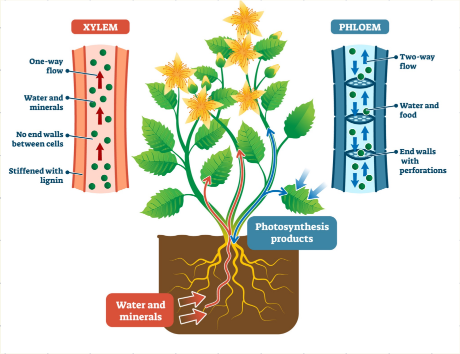
- Catabolic reactions break down larger molecules into smaller molecules
- anabolic reactions build larger molecules from smaller molecules.

Waters solvent properties allows it to be a medium for transport.

In vascular plants:

Dissolved mineral ions are transported in the xylem from roots to leaves

Dissolved sugars produced in photosynthesis are transported in the phloem sap.



Dissolved solutes can be transported in solution around the body of an organism.

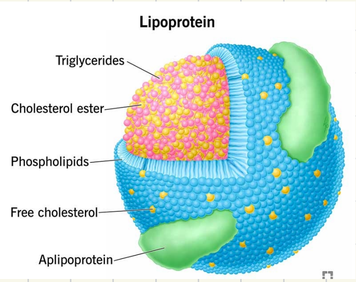
blood transports a range of substances:

. Salt ions (ex: NaCl)
. Amino acids
. Proteins (antibiotics)
. Glucose
. Waste products of metabolism
. A small amount of dissolved gasses

Further details page 16-17

Not everything will transport in water

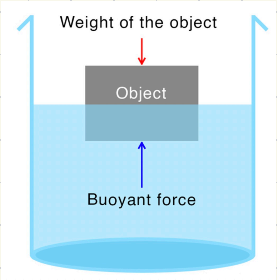
Because they are hydrophobic, lipids can not be directly transported in a solution around the bod y of an organism. in order to be transported in blood fat droplets are first coated in proteins and phospholipids.



A 1.1.6 - physical properties of water and the consequences for animals in aquatic habitats

The physical properties of water contribute to water being the medium of life, which means that water is the substance upon which life exists. A physical property is a measurable behavior or characteristic of matter that exists without the matter reacting or interacting with other things.

Physical property: buoyancy

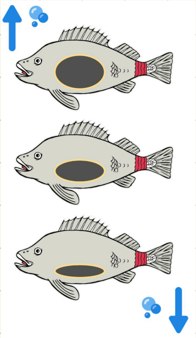


Buoyancy is an upward force applied to an object that is immersed in a fluid. If the buoyant force of the fluid is greater than the objects weight, the object will float.

Buoyancy depends on density

1. If the density of the object is lower than the density of the fluid, the buoyant force will be greater than the force due to gravity, so the object will float.
2. If the density of the object is greater than the density of the fluid, the buoyant force will be less than the force due to gravity, the object will sink.

Living organisms have an overall density close to that of water. This makes it easier for them to use water as a habitat.



Bony fish have an air-filled swim bladder which they use to control their overall density.

Air is much less dense than living organisms and provides negligible amounts of buoyancy.

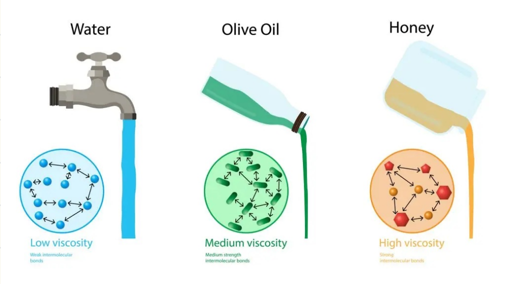
Physical property: viscosity

Viscosity is a measure of a fluid's tendency to flow-viscosity is due to the amount of friction the molecules of a liquid experience as they flow over each other.

When a fluid flows through a tube, the velocity is greater in the center of the tube than at the edges so there is internal frictions.

The more viscous a fluid, the greater the friction and the resistance to flow.

Solutes increase the viscosity even further, so blood does not flow as easily as water.



Physical property; thermal conductivity

The rate at which heat passes through a material is known as thermal conductivity. Fats and oils conduct heat 25% as quickly as water.

Aquatic warm-blooded animals are at much greater risk of the loss of body heat than land-based warm animals.

Water is useful when there is a need to absorb or transfer heat.

*A thick layer of fat provides insulation from cold ocean temperatures in marine animals.

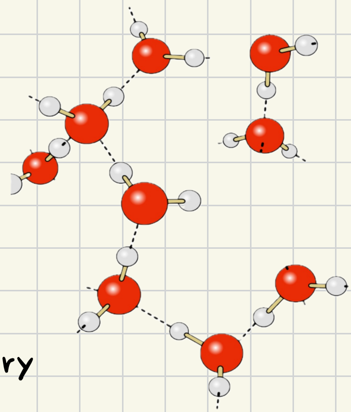
*A person will more quickly become hypothermic in cold water than in cold air because the water rapidly conducts body heat away from the body,

A1.1.6—Physical properties of water and the consequences for animals in aquatic habitats
Include buoyancy, viscosity, thermal conductivity and specific heat capacity. Contrast the physical properties of water with those of air and illustrate the consequences using examples of animals that live in water and in air or on land, such as the black-throated loon (*Gavia arctica*) and the ringed seal (*Pusa hispida*). *Note: When students are referring to an organism in an examination, either the common name or the scientific name is acceptable.*

Physical property: specific heat capacity

The heat required to raise the temperature of 1 g of a material by 1°C is its specific heat capacity.

The SHC of water is: 4.18 JgK
The SHC of air is: 1.01 Jgk



Water has a high SHC because hydrogen bonds restrict molecular motion. For temperature of water to increase, hydrogen bonds must be broken and energy is needed to do this.

As a result, water heats up or cools down very slowly. Which provides a stable internal environment and habitat of living organisms.

Contrasting physical properties of water with those of air

	Buoyant Force	Viscosity	Thermal Conductivity	Specific Heat Capacity
Water	Higher Water applies more upward force than air, allowing objects to float	Higher Water is more resistant to flow	Higher Water absorbs and transfers heat	Higher It takes more energy to change the temperature of water
Air	Lower Air applies less upward force than than water, so most mass does not float in air	Lower Air is less resistant to flow	Lower Heat is lost slower to the air	Lower It takes less energy to change the temperature of air

Black-Throated loon (Gavia arctica) & Ringed Seal (Pusa hispida)

Buoyancy in water allows the seal to stay afloat without expending a lot of energy, however the water is more viscous than air. So the seal has adaptations for stream- lining as it swims through it. Water has a greater thermal conductivity than air, so the Seal needs to insulate itself with blubber to maintain body temperatures. however, water has a SHC, the temperature of water doesn't change as rapidly as the air around it.

Buoyancy in water allows the bird to stay afloat without expending a lot of energy, however when flying through air the bird must expend energy to stay aloft. Air is not viscous.the loon doesn't lose as much body heat to the air because air has a low thermal conductivity. Air has a low SHC, temperature changes rapidly. [Hydrodynamic stream lined shape and] webbed feet.

A1.1.7 - extraplanetary origin of water on earth

A1.1.7—Extraplanetary origin of water on Earth and reasons for its retention
The abundance of water over billions of years of Earth's history has allowed life to evolve. Limit hypotheses for the origin of water on Earth to asteroids and reasons for retention to gravity and temperatures low enough to condense water.

Earth has about 1.4 billion cubic kilometers of water, with 98.3% in liquid form. Water likely wasn't present during Earth's formation due to high temperatures. The leading theory is that water was delivered by asteroid impacts, particularly during heavy bombardment in Earth's early history. Earth retains water due to its optimal distance from the Sun, preventing boiling, and its gravity, which holds water on the surface and in the atmosphere. Mars had water early on, but it was absorbed by minerals in Martian rocks.

A1.1.8 - relationship between the search for extraterrestrial life and the presence of water

A1.1.8—Relationship between the search for extraterrestrial life and the presence of water	
Include the idea of the "Goldilocks zone".	

Liquid water is essential to all known life forms on earth. If a planet is too close to a star, water will vaporize; too far away water will freeze. However, for planets in the Goldilocks zone, the temperature allows water to exist in liquid state.

The location of the Goldilocks zone depends on the size of the star and the amount of energy it emits.it also depends on the size of the planet.

Add-in: properties of water

High boiling point: it allows water to remain liquid over a wide range of temperatures

Low freezing point: ensures water remains liquid at common environmental temperatures.

Expansion: when water freezes, it expands hydrogen bonds move further away from each other. The density of ice is lower than the density of water because it has a greater volume. Because d=m/v. When volume increases the denominator increases.

How different molecules are transported in plasma

Sodium chloride:

- hydrophilic

- can dissolve in water by forming hydrogen bonds as it is ionic

Amino acids:

- can dissolve in water by forming hydrogen bonds, as they have positive and negative charges

- however, their solubility varies depending on the variable part of the molecule, which is hydrophilic in some amino acids and hydrophobic in others. All amino acids are soluble enough to be carried dissolved in blood plasma

Glucose:

- hydrophilic (polar)

- can dissolve in water by forming hydrogen bonds due to glucose being a polar molecule

Oxygen:

- non-polar molecule

- however: the small size of this molecule allows it to dissolve in water sparingly

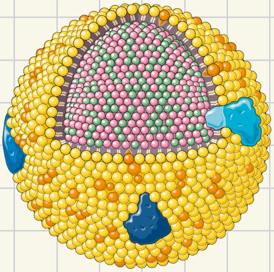
- water becomes saturated with oxygen at low concentration

- as temperature of water increases, the solubility of oxygen decreases

Fat molecules:

- hydrophobic (large molecules) & non-polar

- To prevent large droplets from forming in the blood, small fat droplets are coated in a single layer of phospholipids.



- Phospholipid molecules are hydrophilic in one end and hydrophobic on the other.

- This means they can prevent contact between water and fat, allowing the small fat droplets to remain suspended in blood plasma while being transported around the body.

Latent heat of vaporization: is the amount of energy (enthalpy) that must be added to liquid water to transform it into a gas.