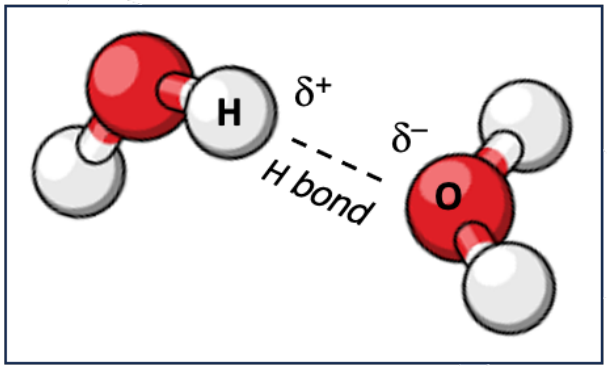
Properties of Water

Introduction

Polarity refers to an uneven distribution of positive and negative charges within a molecule. One end of a water molecule has a slight positive charge (δ^+) and the other end has a slight negative charge (δ^-). This *dipolarity* causes adjacent water molecules to flip around so that the oxygen end of one water molecule is attracted to the hydrogen end of another. The molecules are connected by a *hydrogen bond*.



The polarity of water explains its many properties: including solvation, cohesion versus adhesion, viscosity, buoyancy and thermal conductivity (water has a particularly high specific heat capacity).

Demonstration Stations

The following activities should help you to understand the properties of water and their potential benefits to living organisms. For each activity, in the space provided within the box:

- Summarise your observations in the most suitable form (brief description or diagram)
- Identify and explain the property of water being demonstrated
- Give an example of how this property is important to living organisms

STATION 1: Cohesion / Adhesion

- Fill a glass measuring cylinder with water and then repeat with a plastic measuring cylinder
- Compare the shape of the water's surface in each of the two different measuring cylinders
- Place a drop of water on a glass slide and then put another glass slide on top of the first slide
- Try to separate the two slides by pulling them directly apart

STATION 2: Thermal Properties

- Inflate a balloon with air, then light a match and hold it underneath the balloon
- Fill a balloon with water, then light a match and hold it under the balloon (do this over a SINK)

STATION 3: Polarity

- Adjust a tap to give a steady thin stream of water
- Rub a plastic rod (or an inflated balloon) on a piece of fabric for one minute
- Hold the rod next to the stream of water and observe the water flow

STATION 4: Surface Tension I

- Fill a beaker with tap water and then sprinkle nutmeg onto the surface of the water
- Carefully add one drop of detergent to the centre of the water's surface

STATION 5: Surface Tension II

- Place drops of water and methanol on the surface of a glass side and observe their spread
- Fill a beaker with 50 ml of water and carefully place a paper clip on the surface of the water
- Fill a beaker with 50 ml of methanol and carefully place a paper clip onto the surface

STATION 6: Capillary Action

- Observe coloured liquid in a variety of pre-prepared tubing with different diameter lumens

EXTENSION: Metabolic Reactions

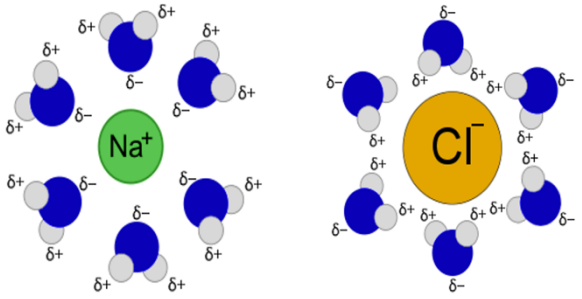
- Outline the role water plays in anabolic (condensation) and catabolic (hydrolysis) reactions

Water Transport

Water is a solvent of polar substances (will dissolve), but is not a solvent of non-polar substances. This explains the way different chemicals are transported in blood plasma (roughly 90% water).

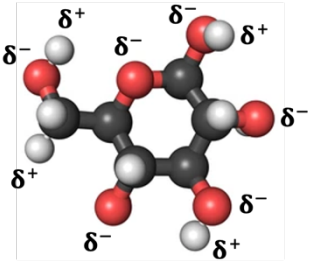
Ions

Ions (such as Na^+ and Cl^-) are charged particles, so they can freely dissolve in plasma. Water molecules surround the charged cations and anions and form hydration shells to separate them (polar associations are weaker than ionic bonds, but sufficiently large quantities of polar molecules can dissociate the ions).



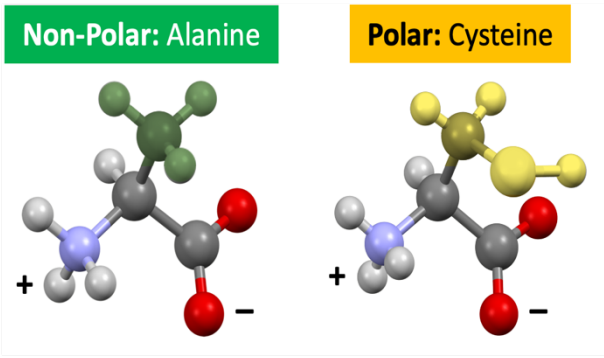
Glucose

Monosaccharides (like glucose) are polar because they contain many OH groups (oxygen is electronegative). However, polysaccharides tend to be far less soluble as the individual sugars are far more likely to form hydrogen bonds with each other, which reduces the capacity for water to interact with the polymer (plus oxygen is lost during polymerisation).



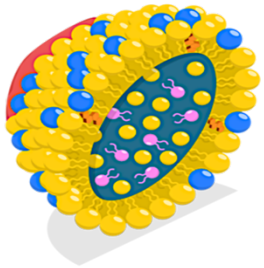
Amino Acids

Amino acids vary in their polarity. Some have polar side chains, others have non-polar side chains. However, they are sufficiently soluble to dissolve in water because of the polarity of the amine (NH_3^+) and carboxyl (COO^-) groups that form a backbone. The solubility of large proteins is dependent on the number and location of the non-polar amino acids.



Cholesterol and Fats

Cholesterol and fats (triglycerides) are non-polar and so will not dissolve in water (they are hydrophobic). They must be transported to the liver via lymph vessels, where they are packaged into a capsule with components that are polar (proteins and phospholipids). These complexes (lipoprotein or chylomicron) are water soluble and can be transported within the blood.



Respiratory Gases

The respiratory gases (oxygen and carbon dioxide) are both non-polar, however their solubility in water differs. Oxygen has low solubility in water and must be transported within the blood by haemoglobin (found in red blood cells). Carbon dioxide reacts with water to form carbonic acid, which is a polar substance. In the blood, the carbonic acid dissociates into bicarbonate ions (and hydrogen ions) for transport in the plasma.