

Describe and explain the biological importance of water

Water is the most important substance for all living organisms, without it life wouldn't exist. Water is a large component of cells, forming between 70% and 95% of the mass of a cell. It also provides a habitat for water dwelling organisms.

Water molecules are able to form hydrogen bonds with other water molecules. This allows water molecules to remain a liquid at normal Earth temperature, normally molecules of this size would be a gas at Earth temperature. As water is a liquid it provides a suitable environment for ions and molecules to move around in and somewhere life can develop.

Ice is less dense than water. This means ice floats insulating the water beneath it. This helps to prevent oceans and lakes freezing completely, preserving the organisms in the water. This allows the ice to thaw quickly as the temperature increases. The changing density helps to maintain the circulation of nutrients in large amounts of water

Water is transparent. This allows plants to grow in shallow water, as photosynthesis is able to take place.

Water provides a medium for biochemical reactions to take place. Water is also used as a reagent in photosynthesis and to hydrolyse macromolecules to their subunits.

Due to the cohesive forces between water molecules it is an ideal medium for support as it is very hard to compress. An example of its use for support is the amniotic fluid, which supports and protects the mammalian foetus.

The weak nature of single hydrogen bonds means water molecules can move easily allowing the uptake and movement of water (osmosis) to happen.

As water has cohesive and adhesive properties it is viscous. This makes it an effective lubricant in biological systems. For example synovial fluid lubricates the joints of many vertebrates.

A large amount of energy is required to increase the temperature of water. Bodies largely composed of water are thermostable, therefore less prone to heat damage caused by changes in the environment temperature.

Water is balanced at the Earth's temperature so the water cycle of evaporation, transpiration and precipitation is sustained.

In plants a continuous channel of water is able to move up the xylem due to the cohesion between water molecules and adhesion between water and the walls of the xylem vessels.

Water is a transport medium for polar solutes. For example it removes metabolic waste such as urea and ammonia in urine.

Water as a solvent

Polar molecules and ions dissolve in water. Polar molecules include sugars and glycerol, which have free hydroxyl groups (OH) projecting from the molecule. Polar molecules carry an unevenly spread charge. This makes some parts of the molecule positive and some parts negative. Water is also a molecule.

When sugar is mixed with water the small positive charge on the hydrogen of the water molecule is attracted to the small negative charge on the oxygen of the sugar. In a similar way the oxygen in water is negatively charged and is attracted to the charged part of the sugar molecule. These forces of attraction make the water molecules stick to the sugar with hydrogen bonds. This separates the sugar molecules. The sugar therefore dissolves. Water's ability to act as a solvent allows the dissolving chemical to move about more freely and react together. We say that the sugar molecules are hydrophilic.

Non polar molecules like lipids are insoluble in water. If lipids are mixed with water the water molecules stick to each other. This pushes the non polar (lipid) molecules together in a blob or a droplet. This is a hydrophobic interaction.

Thermal Properties, Density and Freezing

A) Why is an unusual amount of energy needed to raise the temperature of water?

A large amount of energy is needed because hydrogen bonding restricts the movement of water molecules.

B) How does this property of water help living things?

It creates a more stable habitat for water dwelling organisms and it minimises internal changes in body temperature making it easier to maintain a stable body temperature.

C) Why is evaporation of water particularly effective as a means of cooling the body?

The high latent heat of vaporisation of water means that a body can be considerably cooled with a minimal loss of water.

D) What makes it difficult for water to freeze?

Ice is less dense than water. This means ice floats insulating the water beneath it therefore preventing large amounts of ice being formed.

E) Water is less dense as a solid than as a liquid. Give 2 reasons why this is advantageous.

It helps to prevent whole oceans and lakes freezing and increases the chance of water dwelling organisms surviving.

F) What property of water leads to high surface tension and cohesion?

Water molecules tend to stick to each other because of the hydrogen bonding between them.

Properties of water and their biological significance

Property of water	Reason for this property	Value of this property to living things
Solvent for polar molecules like sugar and glycerol	Water molecules are attracted to them, collect around and separate them.	Most processes in living organisms take place in solution in this way e.g. removal of urea and ammonia in urine.
Non polar molecules are hydrophobic and are pushed together by water molecules	Water molecules are attracted to each other.	It increases the stability of structures such as protein and membrane structures
High energy is needed to increase its temperature	Hydrogen bonding restricts the movement of water molecules.	It provides a more stable habitat for organisms and internal body temperature changes are minimised
It is more dense as a liquid than as a solid	Water expands as it freezes, therefore making ice less dense than liquid water.	Reduces likelihood of large amounts of water such as oceans and lakes freezing completely, increasing the chance of life in cold conditions.
Water molecules stick to each other	Hydrogen bonds cause water molecules to stick together.	Creates a high surface tension at the surface of water allowing small organisms such as pond skaters to use the surface as a habitat and to skate over the water.