TeachMe

STUDY NOTES

A1.1 WATER

Last update: August 5th 2026

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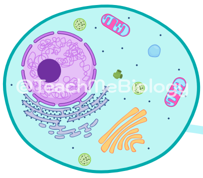
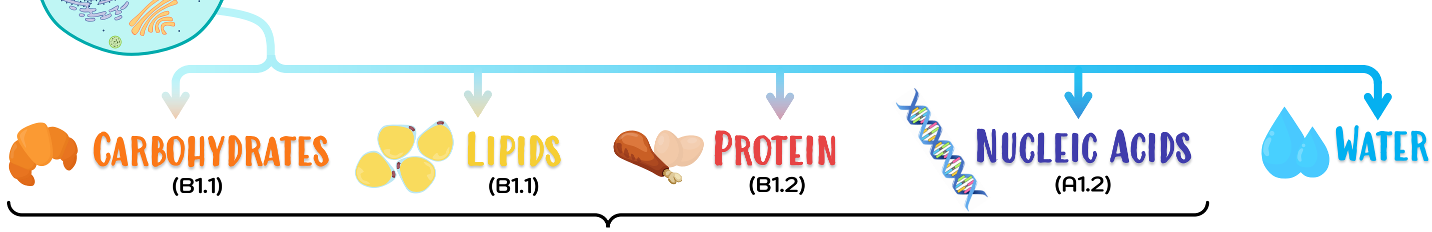
WATER



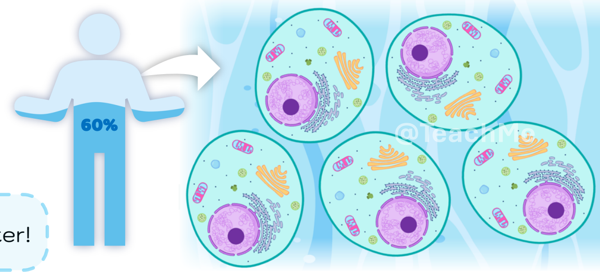
Our bodies are built from CARBOHYDRATES, LIPIDS, PROTEINS and NUCLEIC ACIDS, all of which we'll learn more about in later chapters — but the molecule we contain more of than any other is WATER.



- Habitat
- Blood & bodily fluids
- Cells & Organelles
- Between cells

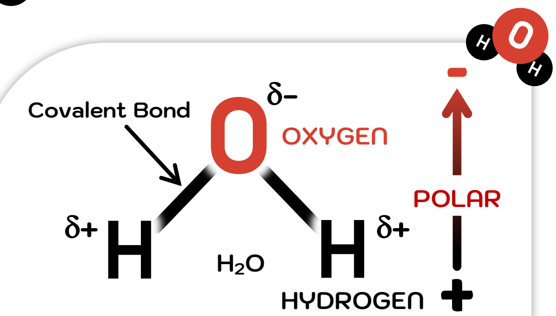
Water is found **everywhere**! It fills our cells and organelles, surrounds them as extracellular fluid, and makes up most of our blood and bodily fluids — all while serving as a vital habitat for countless organisms.

In fact, about **60%** of the human body is made of water!



What exactly is water?

Water is a molecule made up of one OXYGEN (O) atom and two HYDROGEN (H) atoms, linked by **COVALENT BONDS**. This is why water has the chemical formula H_2O (the subscript indicating the number of atoms).

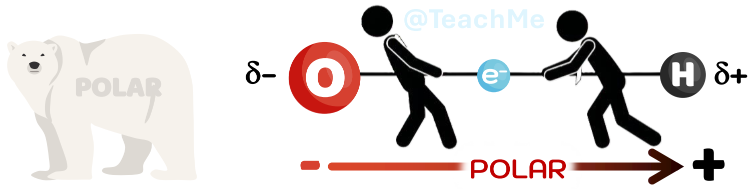


Water is POLAR:
One side of the molecule is more negative, while the other side is more positive.

KEY
δ = "Delta"
δ+ = partial positive
δ– = partial negative

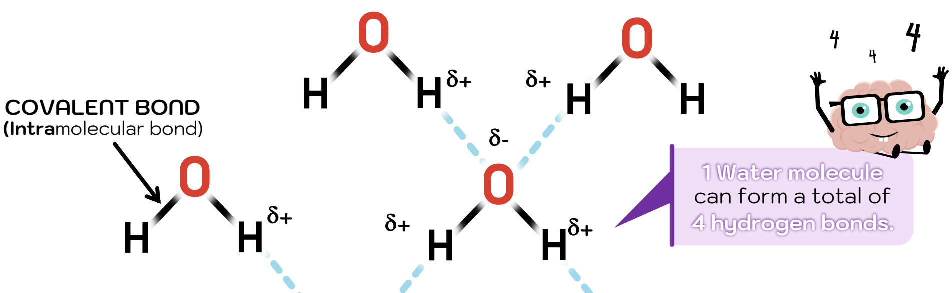
In each **COVALENT BOND**, oxygen and hydrogen share a pair of electrons.

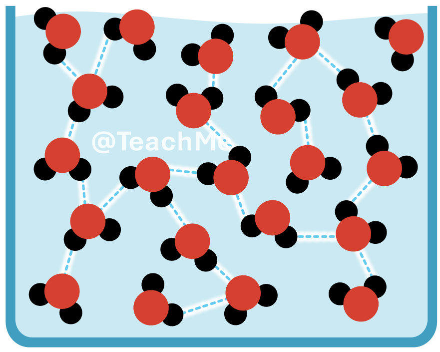
Oxygen, however, pulls the electrons harder (greedier) than hydrogen does — like a tug-of-war where **oxygen is winning**, giving it a **partial negative charge (δ-)** (electrons are negatively charged). Relatively, hydrogen has therefore a **slight positive charge (δ+)**.



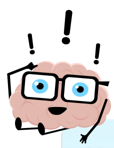
ELECTRONEGATIVITY = how "**greedy**" an atom is for electrons. So, oxygen is more electronegative than hydrogen: there is an unequal distribution of charge.

The **δ+ hydrogen** of one water molecule is attracted to the **δ– oxygen** of another (opposites attract). These attractions are called HYDROGEN BONDS.

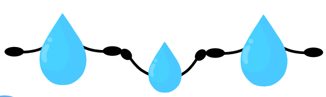




In liquid state, hydrogen bonds are continually breaking, reforming and moving around.



BIG BRAIN TIP!
Hydrogen bonds are hyding:
Weaker than covalent bonds



This causes water molecules to stick together – giving water its special properties (page 2).

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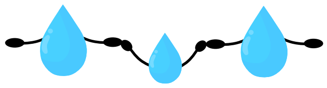
Although each hydrogen bond is **weak**, the large number of them between water molecules gives water several **UNIQUE PROPERTIES** that are essential to life. These include:

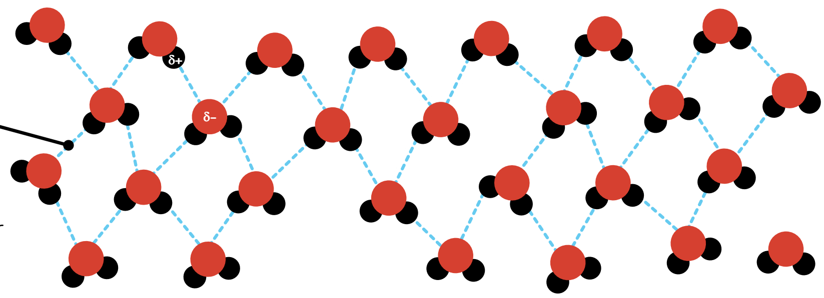
COHESION

When molecules of the **same** type are attracted to each other.
water – water

Because each water molecule can **hydrogen bond** with neighboring water molecules, many water molecules are held together as a group.

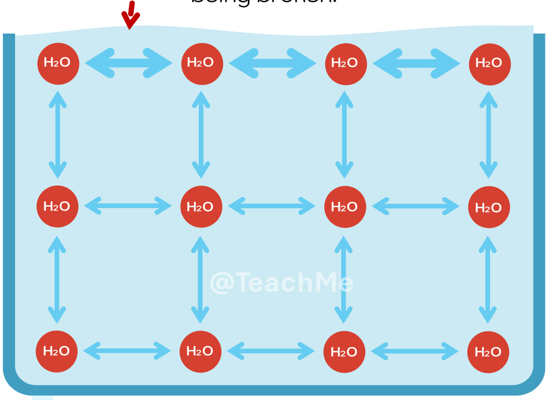


Bonding between water molecules
Hydrogen bond

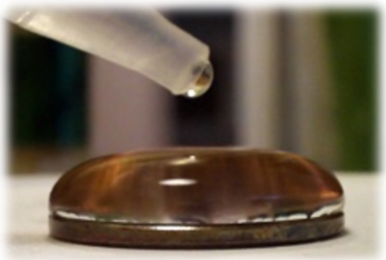


Water molecules below the surface are attracted to other water molecules in all directions.

SURFACE TENSION
Resistance of a liquid's surface to being broken.



Water molecules at the surface have no water molecules above them, so they experience a net inward attraction. This pulls the surface molecules together, creating **SURFACE TENSION.**

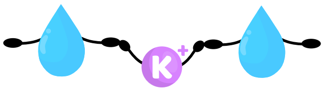


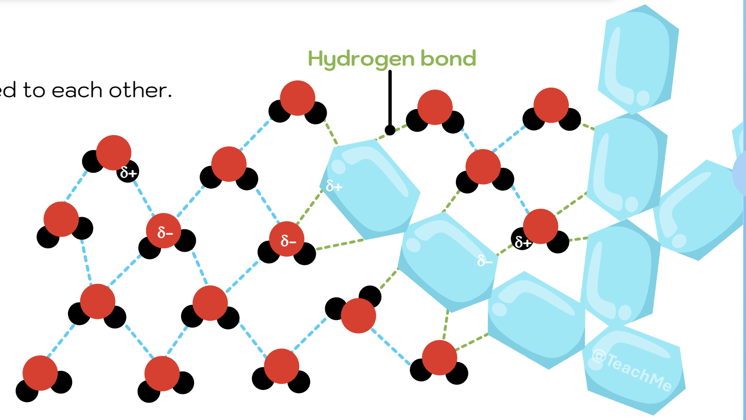
High surface tension → supports small organisms on the water's surface.

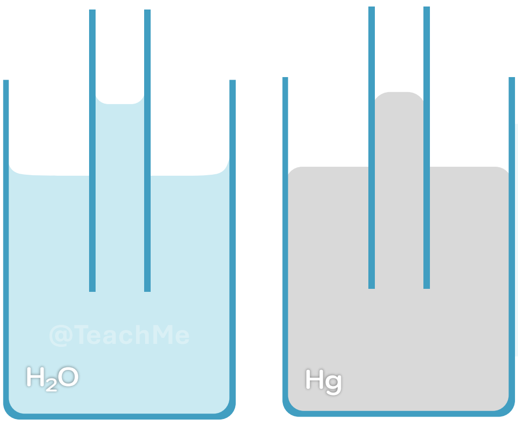
ADHESION

When **unlike** molecules are attracted to each other.
water – other substance

Because water is **polar**, it can form attractions with **other polar or charged substances** (e.g., glucose).
This causes water molecules to stick to other surfaces.







This is why you can observe that **when** water is place in a glass, the water is strongly attracted to the glass (**Adhesion > Cohesion**).
→ Water climbs slightly up the sides of the tube, forming a CONCAVE MENISCUS.

On the other hand, **mercury** (Hg) atoms are more strongly attracted to each other than to the glass (**Cohesion > Adhesion**).
→ Mercury pulls away from the sides, forming a CONVEX MENISCUS.

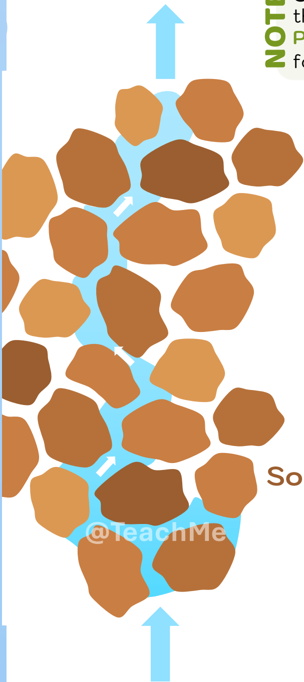
COHESION and ADHESION describe two different attractions involving water molecules. But these properties don't always act independently — they can also work together → next page

Capillary Action

Movement of a liquid up a narrow tube due to the combined effects of **COHESION** and **ADHESION**.

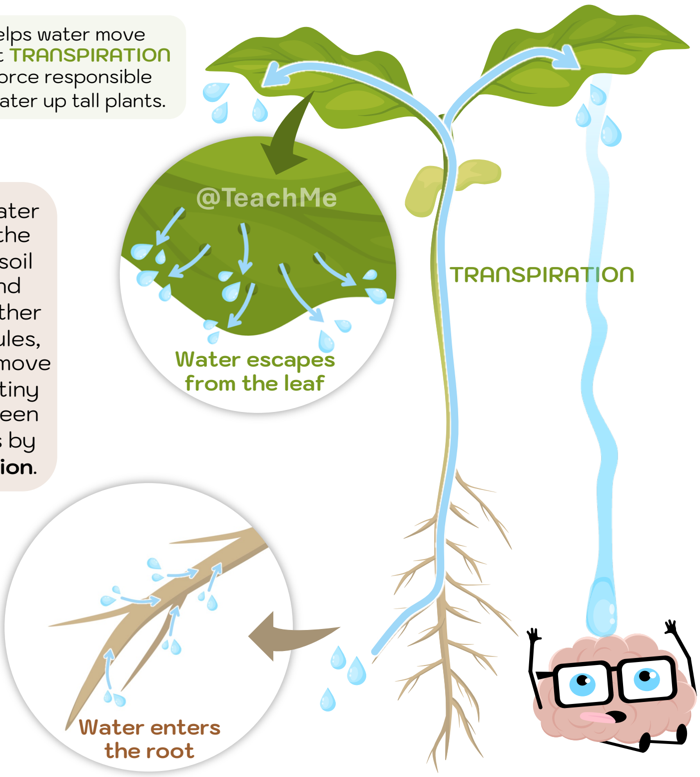
In the narrow xylem vessels, water **ADHERES** to the vessel walls, while **COHESION** keeps water molecules attracted to each other. Together, these properties cause water to move up the narrow vessels by **CAPILLARY ACTION**.

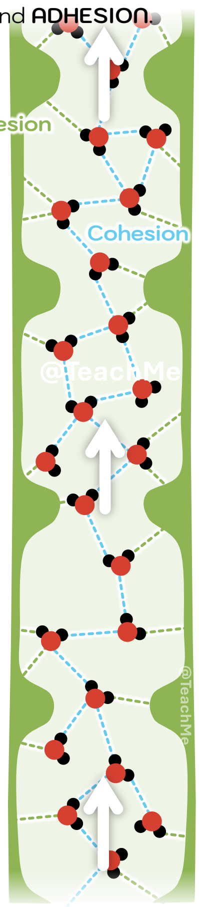
NOTE! **Capillary action** helps water move through xylem, but **TRANSPIRATION PULL** is the main force responsible for transporting water up tall plants.



In the **soil**, water adheres to the surfaces of soil particles and coheres to other water molecules, allowing it to move through the tiny spaces between soil particles by **capillary action**.

Soil

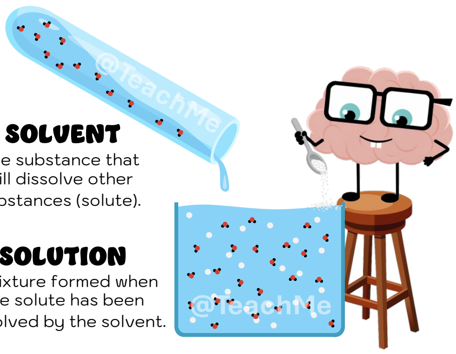




UNIVERSAL SOLVENT

→ Great solvent for polar molecules.
→ Poor solvent for non-polar molecules.

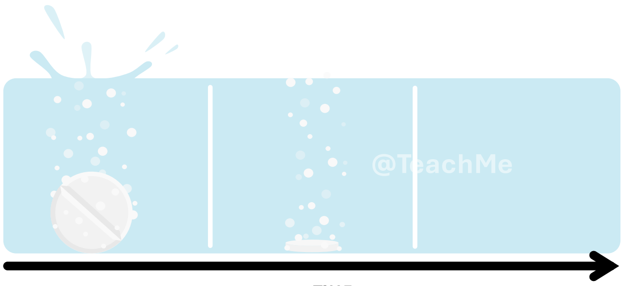
Water is called the **UNIVERSAL SOLVENT** because it can dissolve **more substances than most liquids** — especially ionic and polar substances. It does **NOT** dissolve everything, e.g., oils and fats.



SOLVENT
The substance that will dissolve other substances (solute).

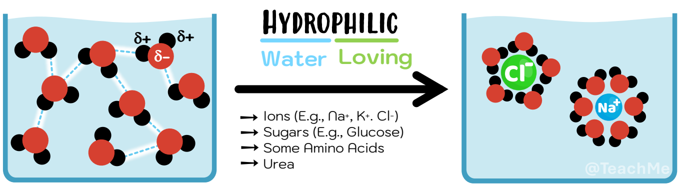
SOLUTION
A mixture formed when the solute has been dissolved by the solvent.

SOLUTE
The substance to be dissolved in a solvent.



For example, when a pill is placed in water, it gradually disappears as its particles separate and spread throughout the water — this is called DISSOLVING.

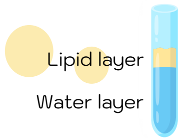
\+ Polar Substance



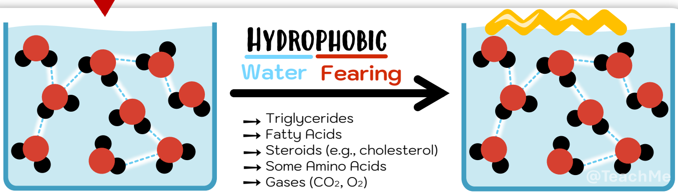
→ Ions (E.g., Na^+, K^+, Cl^-)
→ Sugars (E.g., Glucose)
→ Some Amino Acids
→ Urea

The partially charged ends of the water molecules are attracted to ions and other polar molecules, they surround the solute particles and pull them apart, allowing them to disperse throughout the water → this is what **DISSOLVING** is.

You probably tried this before: placing oil in water



\+ Non-Polar Substance



→ Triglycerides
→ Fatty Acids
→ Steroids (e.g., cholesterol)
→ Some Amino Acids
→ Gases (CO_2, O_2)

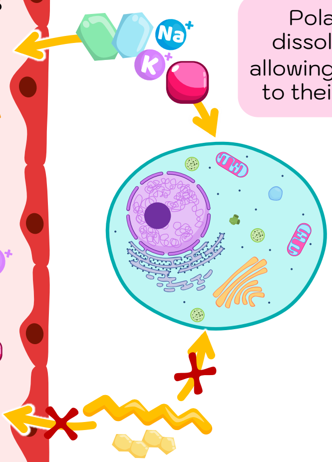
NON-POLAR substances cannot form favorable attractions with water. Water therefore does not surround and separate their molecules, so they do not dissolve and tend to **group together away from water**.

Biological implications:

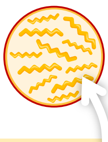
Why is the property of water as a universal solvent important?

(1) Transport medium (mostly)

→ Bloodstream (in animals)
→ Xylem & Phloem (in plants)



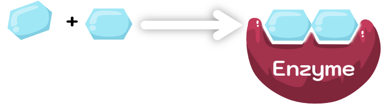
Polar molecules are easily dissolved in the bloodstream allowing them to get transported to their target cells efficiently.

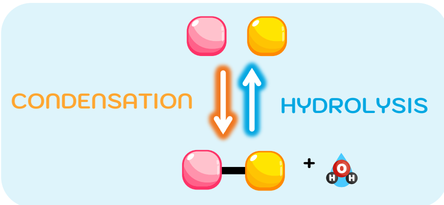


In comparison, non-polar molecules such as lipids require means of transport to be carried around.

(2) Chemical reactions

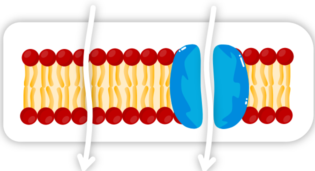
→ Solvent – Bringing reactants together
→ Reactant – Hydrolysis reactions
→ Product – Condensation reactions





(3) Cell Membrane

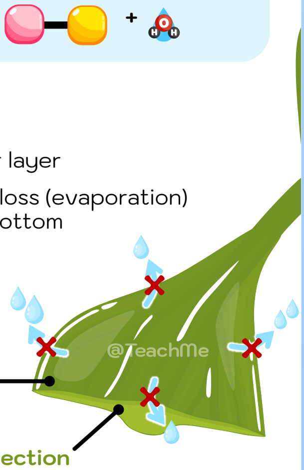
→ Non-polar substances may pass directly as the membrane is also non-polar.
→ Polar substances need assistance (transport proteins).



(4) Cuticle

A non-polar layer

→ Barrier to water loss (evaporation)
→ Top more than bottom

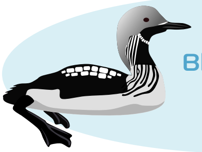


Waxy cuticle (shiny surface)

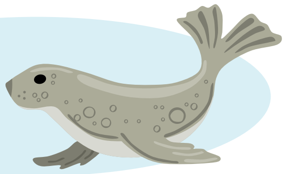
Leaf cross section

The **Black-throated loon** and **Ringed seal** live in cold **Arctic and sub-Arctic** environments and spend much of their lives in or around water. Living in water presents both advantages and challenges because water has very different physical properties from air.

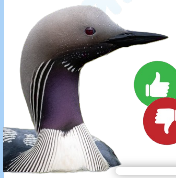
We will explore the next 4 properties of water, compare them with air, and see how they affect these two organisms.



Black-throated Loon
Gavia arctica



Ringed seal
Pusa hispida



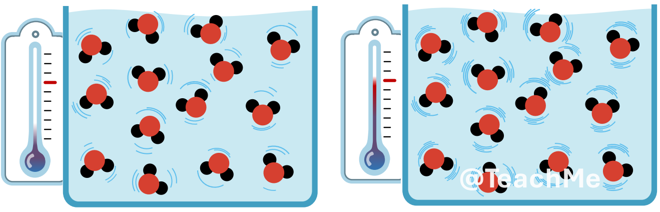
Some properties are **advantageous**, helping the organisms survive in their aquatic environment.
Others present **challenges**, which the organisms have **adaptations** to overcome.

Summary on page 8

SPECIFIC HEAT CAPACITY

The amount of heat energy required to raise the temperature of 1kg (or g) of water by 1°C.

Temperature is average kinetic energy (how fast molecules move).



COLD WATER
Water molecules move slowly

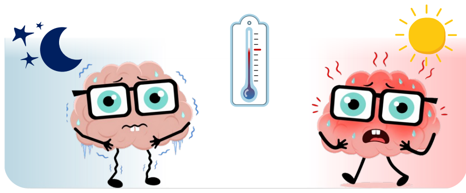
WARM WATER
Water molecules move faster

Water has a **HIGH** specific heat capacity – it takes a lot of heat energy to raise the temperature of water.

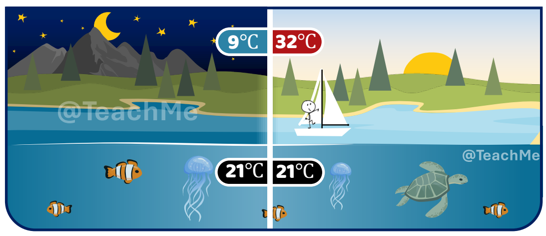
Why?
Because to increase the temperature of water, you need to **break a lot of hydrogen bonds** – that takes a lot of energy.

Biological implications:

(1) Constant body temperature despite air temperature outside
→ Why? Body is mostly water filled cells.
→ Chemical reactions operate relatively constant.

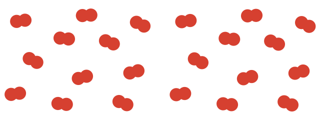


(2) Environmental water (lakes/oceans) has constant temperatures (even between day & night and seasons).
→ Provides stable habitat for aquatic organisms.



WATER VS. AIR

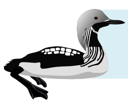
Air has a much **LOWER specific heat capacity** than water.



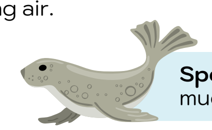
Air **heats up** and **cools down quickly** as environmental temperature changes. In the Arctic, water therefore experiences **smaller and slower temperature fluctuations** than the surrounding air.

ADAPTATIONS

The Black-throated Loon and Ringed Seal spend much of their time in water, where temperatures are more stable than in the surrounding air.



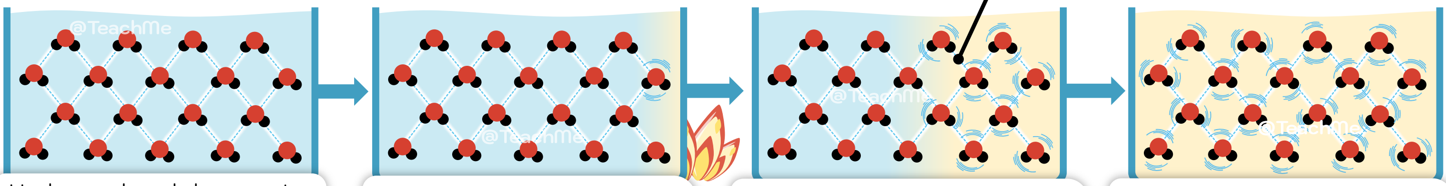
Uses water as a relatively stable thermal environment for **swimming, feeding and breeding**.



Spends most of its life in water, avoiding the much larger temperature fluctuations of Arctic air.

THERMAL CONDUCTIVITY

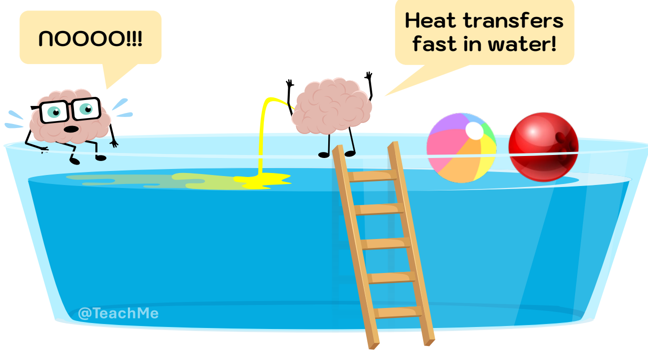
→ The ability of a substance (Eg. water) to transfer heat.



Hydrogen bonds keep water molecules close together. → If one side is heated - water molecules gain kinetic energy and move/vibrate faster. → Kinetic energy is readily transferred to neighboring molecules. → Energy is transferred through the water, spreading heat from the warmer to cooler region.

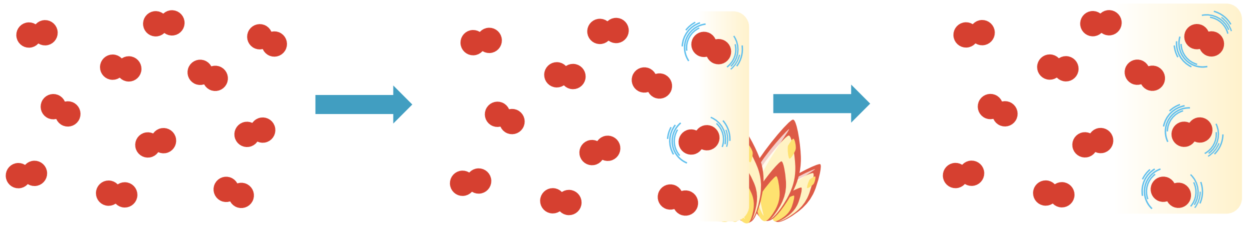
Closely packed particles can transfer heat more readily.

Conducting heat: Solids > Liquids / Gases



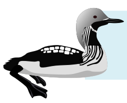
WATER VS. AIR

Water molecules are closer together than molecules in air, heat energy is therefore transferred between molecules more readily.

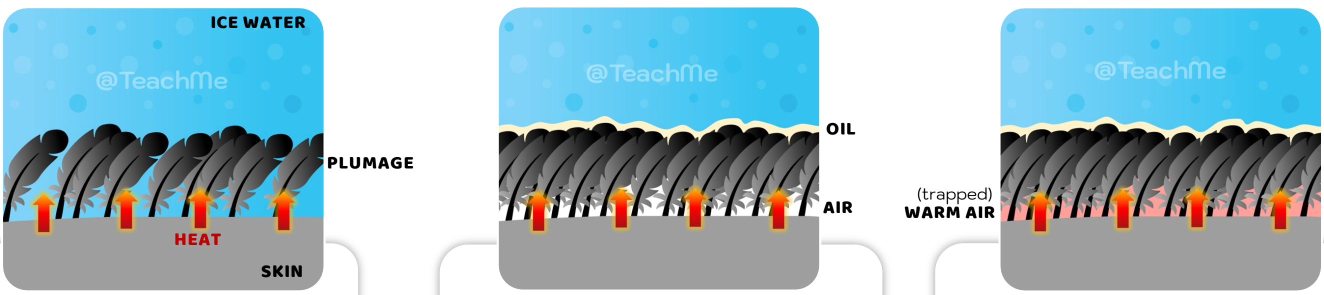


ADAPTATIONS

Animals surrounded by cold water lose body heat much faster than in cold air.



Has an **oil gland near its tail** and uses its beak to spread a thin layer of oil over its feathers, helping make them **waterproof**.

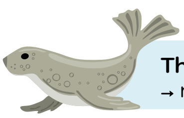


WITHOUT ADAPTATION
Thin plumage allows cold water to reach the skin → rapid heat loss.

THICK, WATERPROOF PLUMAGE
Thick plumage coated with oil keeps water out and traps air between the feathers.

INSULATION
The trapped air warms from body heat and acts as an insulating layer, reducing heat loss to the cold water.

The trapped air reduces the transfer of body heat because air has low thermal conductivity.

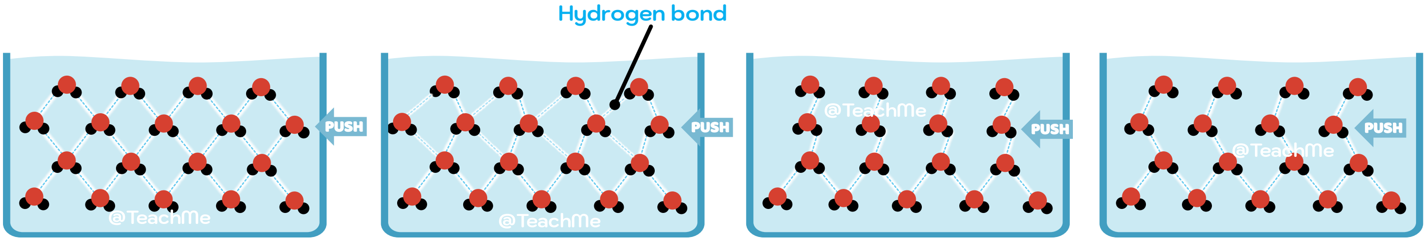


Thick blubber (a very thick layer of fat) under the skin acts as an **insulating layer** → reduces heat loss to the cold water.

VISCOSITY

→ The **resistance** a substance gives (Eg. water) to an object moving through it.

Hydrogen bonds between water molecules must be broken for the molecules to move past each other. This resists movement, giving water its **VISCOSITY**.



WATER VS. AIR

Air has a much **LOWER** viscosity than water.

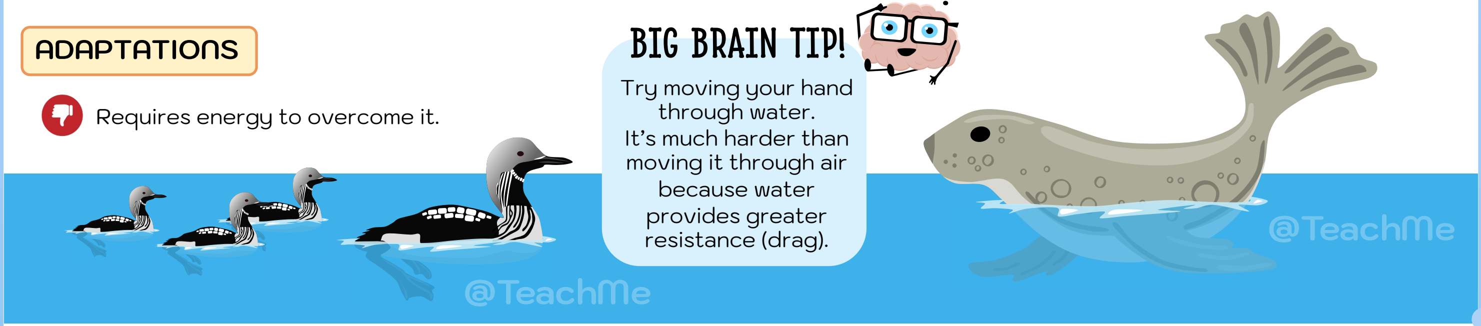
Air molecules are much **farther apar**t and are not held together by hydrogen bonds. Therefore, air provides much **less resistance** to movement than water → less energy is required to move through it (e.g. flying)

ADAPTATIONS

Requires energy to overcome it.

BIG BRAIN TIP!

Try moving your hand through water. It's much harder than moving it through air because water provides greater resistance (drag).



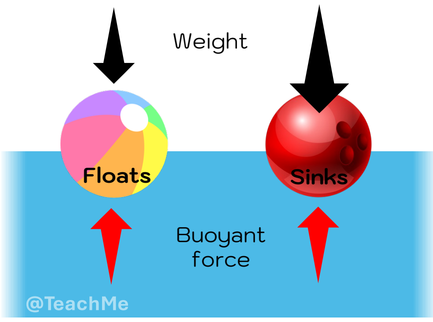
Streamlined body → reduces resistance (drag).
Webbed feet → provide propulsion through the water.

Streamlined body → reduces resistance (drag).
Paddle-like flippers → provide propulsion through the water.

BUOYANCY

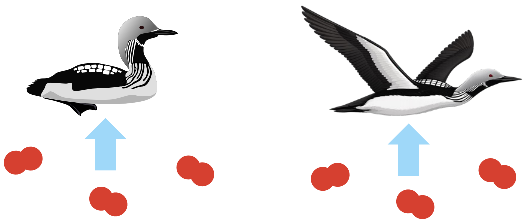
→ An **upwards force** exerted on an object placed on a specific medium (Eg. Water).

When an object is placed in water, it displaces (pushes aside) some water. The displaced water pushes back on the object, creating an upward force called the buoyant force.



WATER VS. AIR

Water provides **MUCH MORE BUOYANCY** than air.

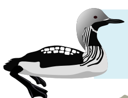


Water is **MUCH DENSER** than air → a much greater buoyant force is produced → making it easier to float in water.

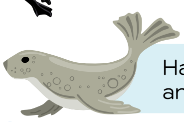
In air, buoyancy is very small → birds must generate **LIFT** with their wings to overcome their weight and fly.

ADAPTATIONS

Helps them float on water.

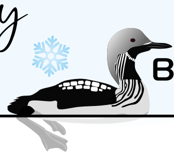


Buoyancy helps it float at the surface with little energy. However, it also has dense bones to reduce buoyancy, making it easier to submerge and dive for fish.



Has a thick layer of blubber (fat), which is less dense than water → further increases buoyancy and helps the seal float. Floating requires little energy, good for resting and breathing.

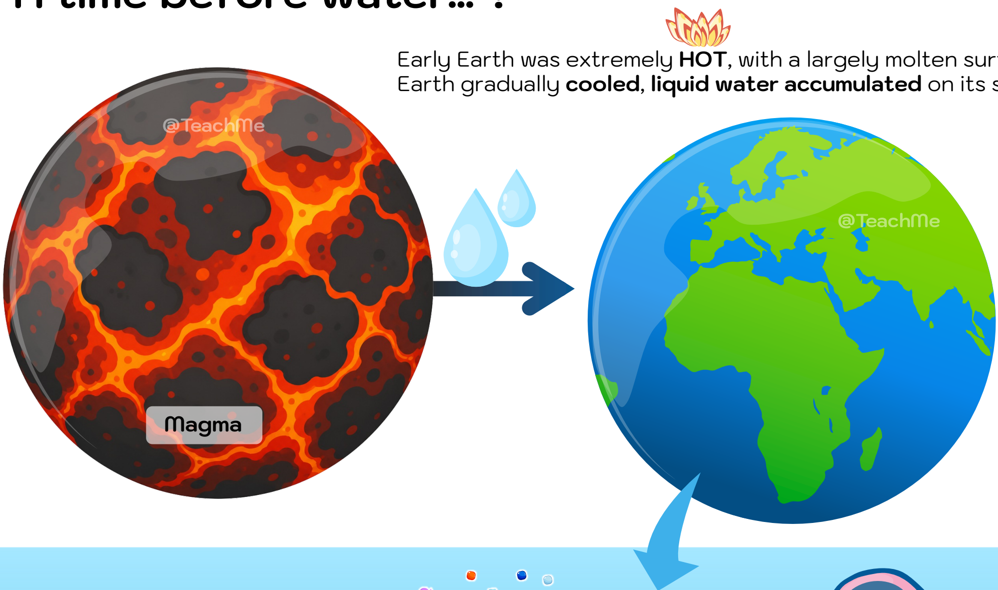
Summary



	Black-throated Loon *Gavia arctica*	Ringed seal *Pusa hispida*
BUOYANCY	Helps it **float**	Helps it **float**
VISCOSITY	Requires energy to overcome the viscosity of the water. E.g. – **webbed feet** and **streamlined body** shape.	Requires energy to overcome the viscosity of the water. E.g. – **paddle feet** and **streamlined body** shape.
SPECIFIC HEAT	Arctic **water** is **warmer** than arctic **air**	Arctic **water** is **warmer** than arctic **air**
THERMAL CONDUCTIVITY	Need to minimize heat loss. **Oil gland** near tail, using beak to rub the oil on the feather making them **waterproof**.	Need to minimize heat loss. Thick **blubber** under the skin (provides insulation).

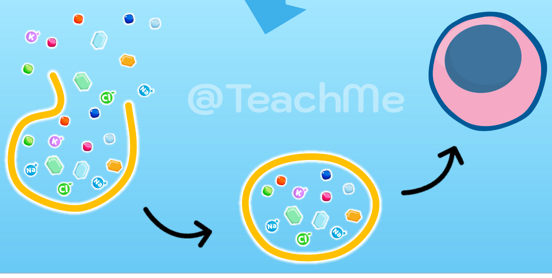
A time before water... ?

Early Earth was extremely **HOT**, with a largely molten surface and intense volcanic activity. As Earth gradually **cooled, liquid water accumulated** on its surface, eventually forming the **oceans**.



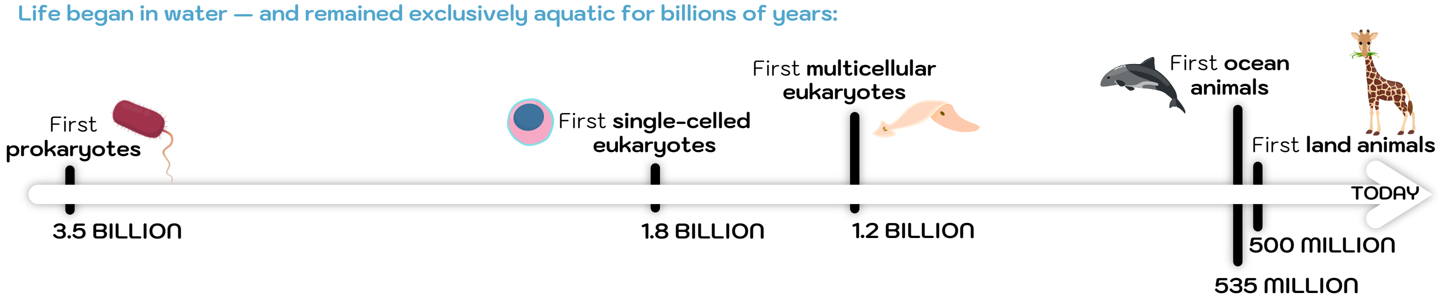
Oceans provided an environment in which simple organic molecules could accumulate and interact. Importantly, water acted as a **solvent**, allowing dissolved substances to move around and react with one another.

At some point, **lipid membranes** formed **compartments**, separating their watery interior from the surrounding environment.



Within these small **compartments**, molecules were concentrated together, making **chemical reactions more likely** and helping create conditions from which the **first cells** eventually **evolved**.

Life began in water — and remained exclusively aquatic for billions of years:



HL In A1.1 Water HL, we will explore the **origins of water** and where it came from — transforming our molten magma planet into the blue planet we know today.

NOTES

notes