TeachMe

STUDY NOTES

UNIT 1 - CHEMISTRY OF LIFE

1.1 Water

Last update: August 4th 2026

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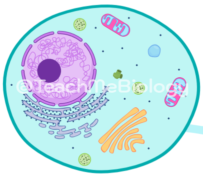
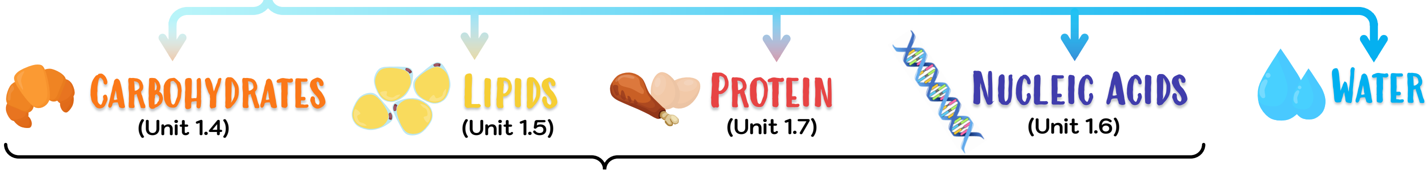
Water



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

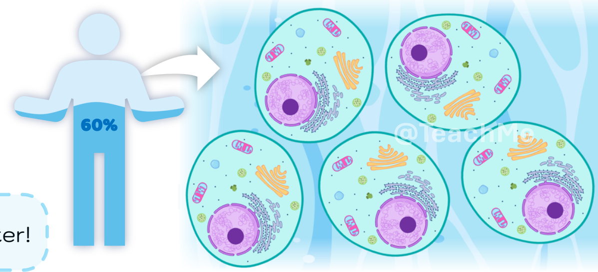


Habitat

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

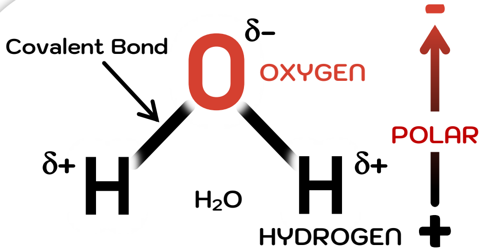
Water is found **everywhere**! It fills our cells and organelles, surrounds them as extracellular fluid, and makes up most of our blood and bodily fluids — all while serving as a vital habitat for countless organisms.

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).

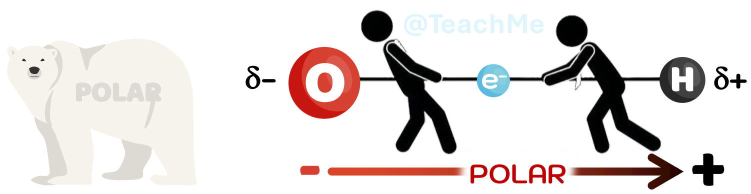


Water is POLAR:
One side of the molecule is more negative, while the other side is more positive.

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

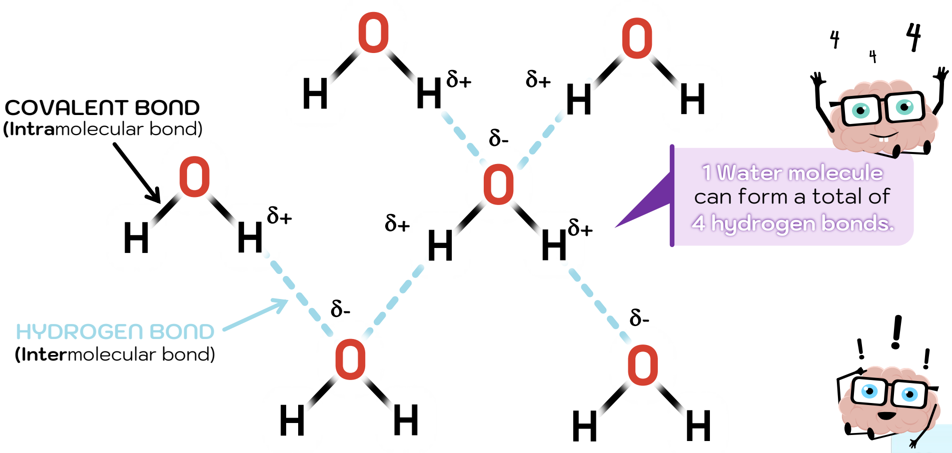
In each **COVALENT BOND**, oxygen and hydrogen share a pair of electrons.

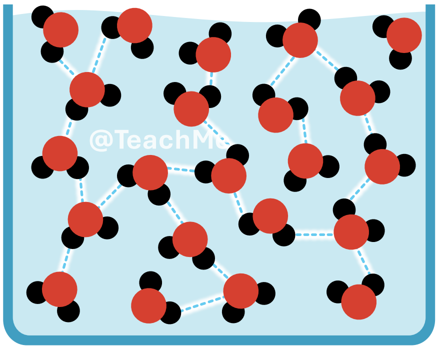
Oxygen, however, pulls the electrons harder (greedier) than hydrogen does — like a tug-of-war where **oxygen is winning**, giving it a **partial negative charge (δ–)** (electrons are negatively charged). Relatively, hydrogen has therefore a **slight positive charge (δ+)**.



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

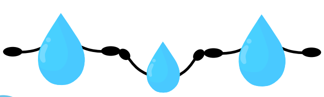
The **δ+ hydrogen** of one water molecule is attracted to the **δ– oxygen** of another (opposites attract). These attractions are called HYDROGEN BONDS.





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 & ADHESION (page 2)

UNIVERSAL SOLVENT (page 3)

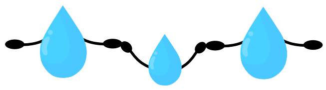
SPECIFIC HEAT CAPACITY (page 4)

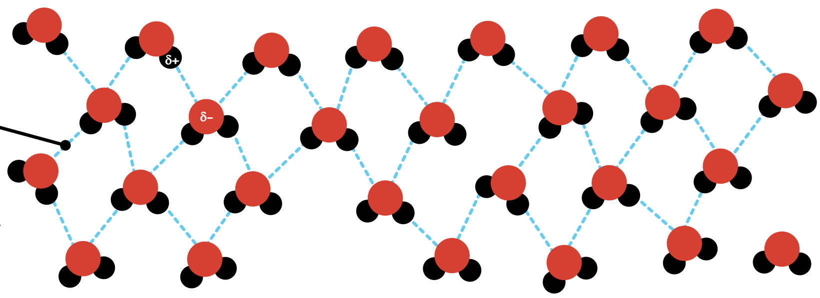
LATENT HEAT OF VAPORIZATION (page 5)

COHESION

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

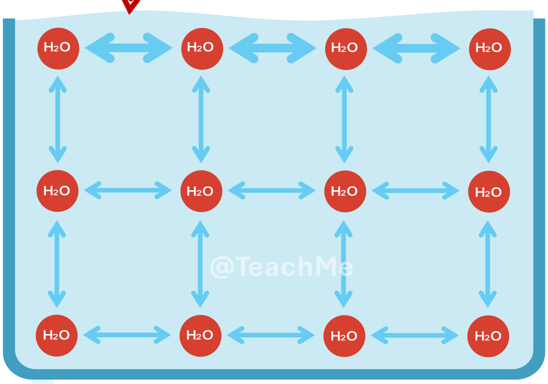
Because each water molecule can **hydrogen bond** with neighboring water molecules, many water molecules are held together as a group.



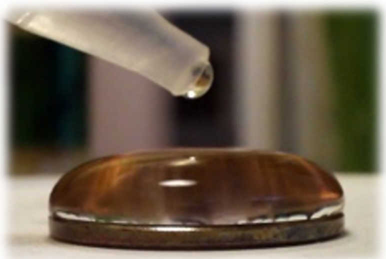


Water molecules below the surface are attracted to other water molecules in all directions.

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



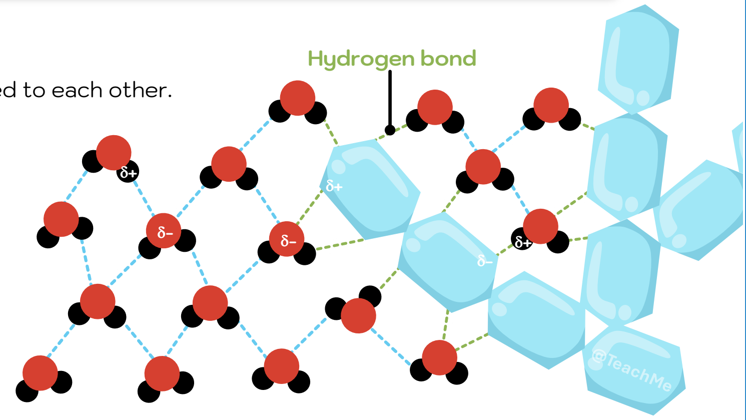
Water molecules at the surface have no water molecules above them, so they experience a net inward attraction. This pulls the surface molecules together, creating **SURFACE TENSION**.



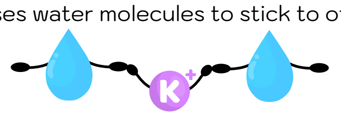
High surface tension → supports small organisms on the water's surface.

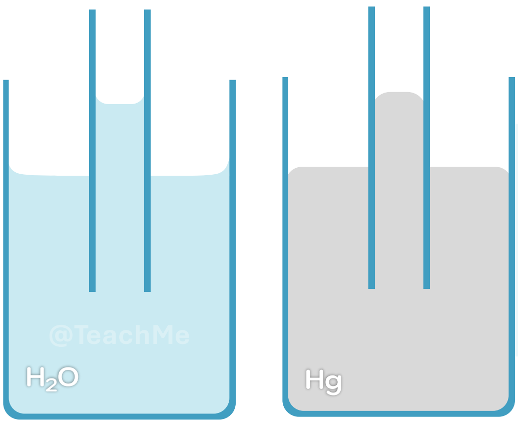
ADHESION

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

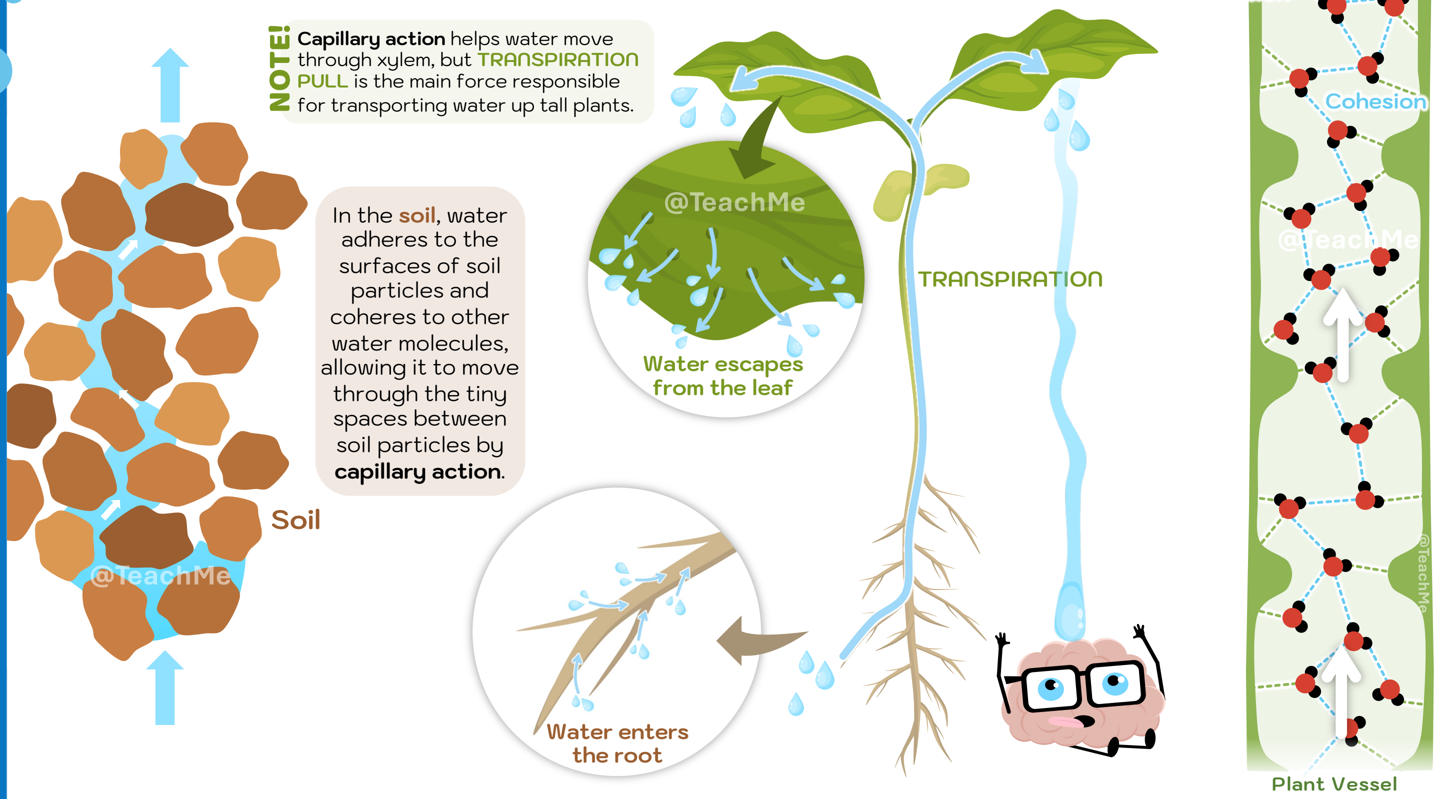
CAPILLARY ACTION

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**.



UNIVERSAL SOLVENT

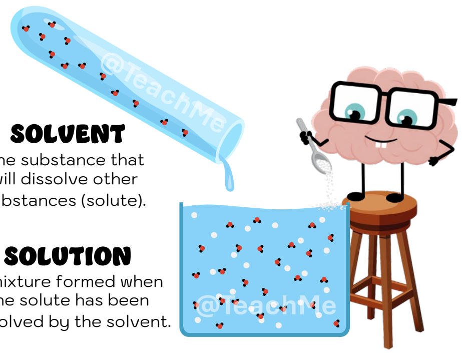
→ Great solvent for polar molecules.
→ Poor solvent for non-polar molecules.

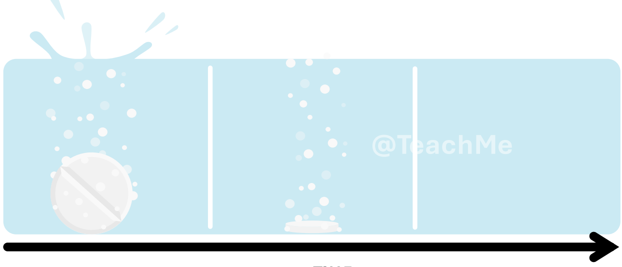
Water is called the **UNIVERSAL SOLVENT** because it can dissolve **more substances than most liquids** — especially ionic and polar substances. It does **NOT** dissolve everything, e.g., oils and fats.

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

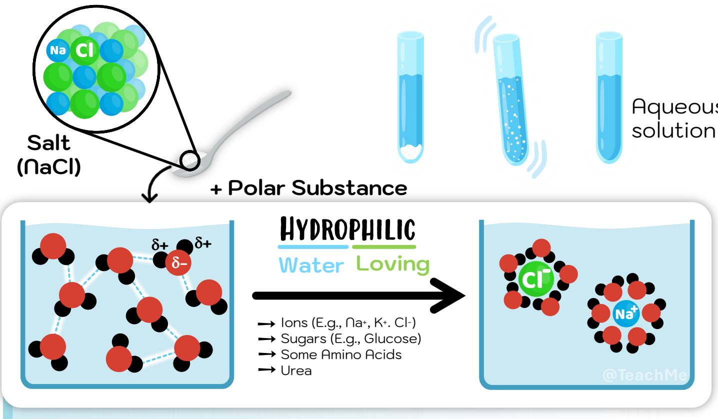
SOLUTE
The substance to be dissolved in a solvent.

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





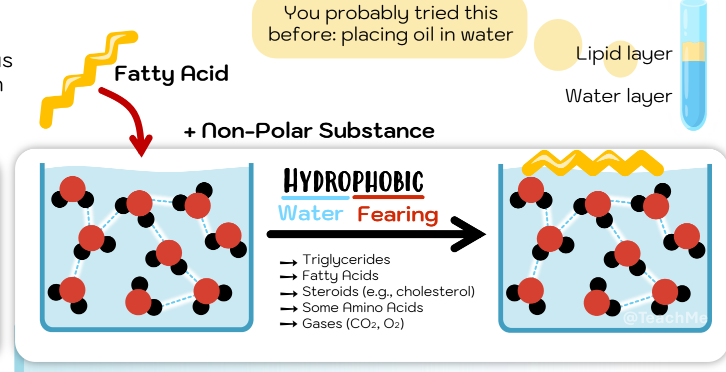
For example, when a pill is placed in water, it gradually disappears as its particles separate and spread throughout the water — this is called DISSOLVING.



- 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



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

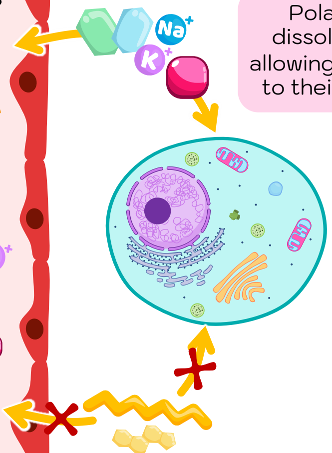
NON-POLAR substances cannot form favorable attractions with water. Water therefore does not surround and separate their molecules, so they do not dissolve and tend to **group together away from water**.

Biological implications:

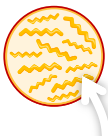
Why is the property of water as a universal solvent important?

(1) Transport medium (mostly)

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



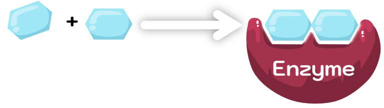
Polar molecules are easily dissolved in the bloodstream allowing them to get transported to their target cells efficiently.

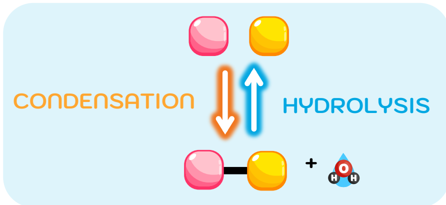


In comparison, non-polar molecules such as lipids require means of transport to be carried around.

(2) Chemical reactions

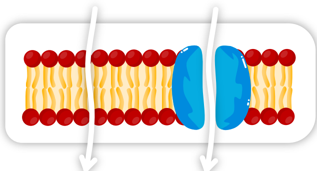
→ Solvent – Bringing reactants together
→ Reactant – Hydrolysis reactions
→ Product – Condensation reactions





(3) Cell Membrane

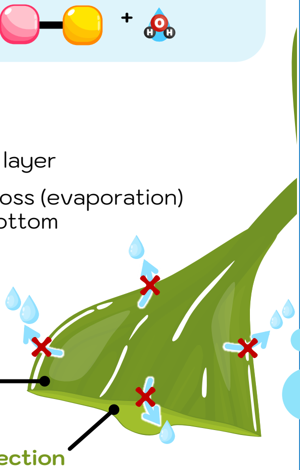
→ Non-polar substances may pass directly as the membrane is also non-polar.
→ Polar substances need assistance (transport proteins).



(4) Cuticle

A non-polar layer

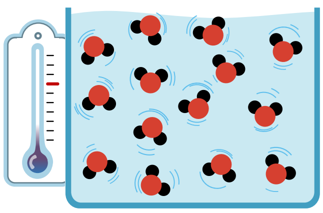
→ Barrier to water loss (evaporation)
→ Top more than bottom



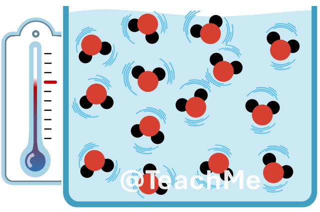
SPECIFIC HEAT CAPACITY

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

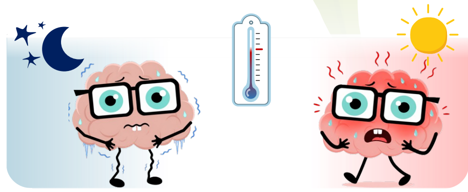
Water has a **HIGH** specific heat capacity – it takes a lot of heat energy to raise the temperature of water.

Why?

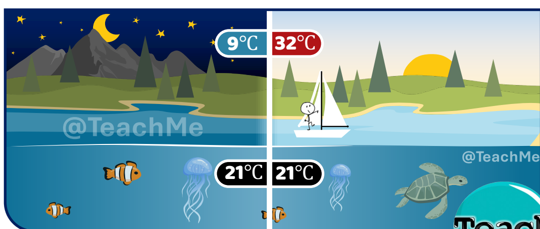
Because to increase the temperature of water, you need to break a lot of hydrogen bonds – that takes a lot of energy.

Biological implications:

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



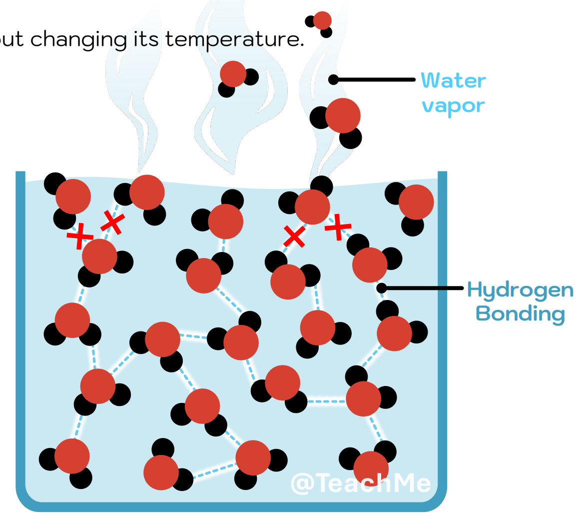
(2) Environmental water (lakes/oceans) has constant temperatures (even between day & night and seasons).
→ Provides stable habitat for aquatic organisms.



LATENT HEAT OF VAPORIZATION

The amount of the heat energy required to vaporize (evaporate) a liquid, without changing its temperature.

Water has a **HIGH** latent heat of vaporization – a lot of energy must be absorbed to break hydrogen bonds and allow water molecules to escape as vapor (gas).



NOTE!

Evaporation ≠ Boiling

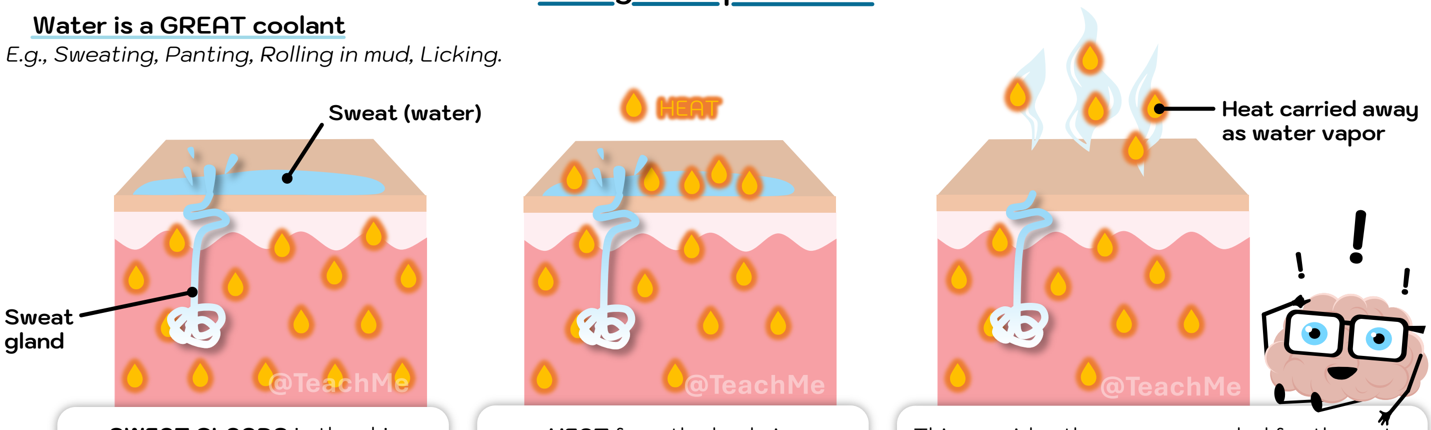
Boiling: Water vapor forms throughout the liquid at **100°C.** (bubbles containing water vapor)

Evaporation: Water molecules escape from the surface at **any temperature** (due to hydrogen bonds breaking at the surface of the liquid).

Biological implications:

Water is a GREAT coolant

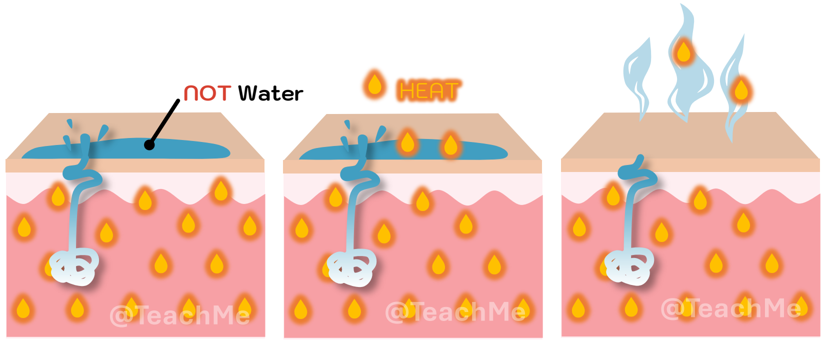
E.g., Sweating, Panting, Rolling in mud, Licking.



SWEAT GLANDS in the skin secrete sweat, containing mostly water, onto the skin surface.

HEAT from the body is **TRANSFERRED TO WATER** on the skin.

This provides the energy needed for the water to evaporate, carrying this energy away as water vapor and the **BODY COOLS**.



Compared with many other liquids, **less heat** would be transferred from the body to evaporate the liquid → less heat would be removed from the body → less cooling.

Notes