IB BIOLOGY · A1.1 · SL AND HL

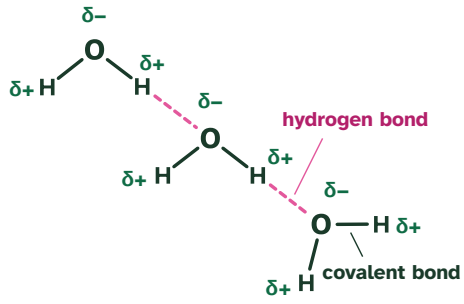
REVISION ON TWO PAGES

Why life runs on *water*

What to know, what to draw and what to say. Nothing else.

THE ONE IDEA

Water molecules are polar, so they form hydrogen bonds. Everything else on this sheet follows from that.



Draw it like this. Solid lines for covalent bonds, dashed for hydrogen bonds, δ+ and δ– on the atoms.

A1.1.2 START HERE

Polar bonds make *hydrogen bonds*

- Oxygen pulls the shared electrons harder than hydrogen does. This **unequal sharing** makes each O–H bond a **polar covalent bond**: the oxygen is slightly negative (δ–) and each hydrogen slightly positive (δ+).
- The δ+ hydrogen of one molecule is attracted to the δ– oxygen of the next. That attraction is a **hydrogen bond**. It forms **between** molecules, never inside one.
- Each hydrogen bond is weak, but there are vast numbers of them. Breaking them takes energy, so water needs a lot of heat to evaporate: that is why sweating cools you.

WHAT HYDROGEN BONDS GIVE WATER — *Cats Avoid Taking Showers*

C	**Cohesion**	water sticks to water
A	**Adhesion**	water sticks to polar surfaces
T	**Thermal**	slow to warm and cool
S	**Solvent**	dissolves ions and polar molecules

A1.1.1

The *medium* for life

- The **first cells arose in water**, more than 3.5 billion years ago.
- Substances dissolve in water, so they can move about, meet and react.
- Water is still the medium in which **most processes of life** happen. Cytoplasm is an aqueous solution, and a cell is about 70% water.
- Land organisms carry their water inside them, in cells, blood and tissue fluid.

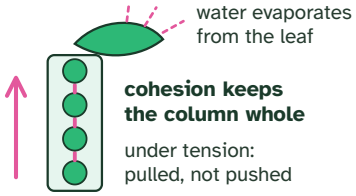
70% of a cell is water

90% of blood plasma is water

A1.1.3 WATER TO WATER

Cohesion

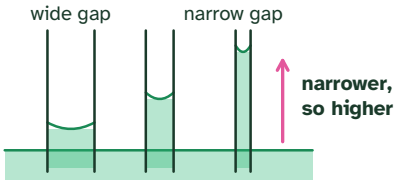
- **Cohesion**: hydrogen bonds hold water molecules to one another.
- **In xylem:** evaporation from leaves pulls water up. Cohesion keeps the column unbroken, so it is pulled up **under tension**.
- **At the surface:** molecules are pulled sideways and inwards, so the surface acts like a stretched film: **surface tension**. Pond skaters use it as a habitat.



A1.1.4 WATER TO OTHER THINGS

Adhesion

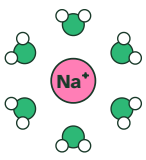
- **Adhesion**: water is attracted to materials that are **polar or charged**.
- **Capillary action**: water adheres to the sides of a narrow space and creeps along; cohesion drags the rest behind.
- **In soil:** water is held between the particles and creeps towards roots.
- **In plant cell walls:** water soaks between the cellulose fibres, keeping the walls wet.



A1.1.5

The *solvent* cells run in

- Water surrounds ions and hydrogen-bonds with polar molecules, so a **wide variety of hydrophilic substances dissolve**.
- **Metabolism:** most **enzymes catalyse reactions in aqueous solution**, where enzyme and substrate can meet.
- **Transport:** blood plasma, xylem sap and phloem sap carry dissolved substances.
- Some molecules work **because they are hydrophobic** and insoluble.



The δ– oxygens face the positive ion

Hydrophilic polar or charged

Ions (Na^+, Cl^-), glucose, amino acids, urea. They dissolve, so they can react and be carried.

Hydrophobic non-polar, insoluble

Wax on a leaf keeps water in. **Fat** stores energy without dissolving. **Phospholipid tails** make a membrane a barrier.

Water as a *habitat*, and water beyond Earth

A1.1.6 COMPARE WATER WITH AIR, AND SAY WHAT IT MEANS FOR AN ANIMAL

Life in water, life in *air*

PROPERTY	WATER AGAINST AIR	BLACK-THROATED LOON *Gavia arctica*	RINGED SEAL *Pusa hispida*
B **Buoyancy** the upward push of a fluid	**Over 800 times as dense.** Water holds a body up; air gives almost no support.	Floats so well that it must work to dive: its bones are dense and it squeezes the air from its feathers.	Water carries its weight, so its flippers are free to drive and steer. On the ice it must haul itself along.
V **Viscosity** resistance to flow	**About 55 times as viscous.** Moving through water meets far more drag.	A streamlined body, with webbed feet set far back to drive it after fish.	A smooth torpedo shape with no ear flaps cuts the drag; hind flippers push it along.
T **Thermal conductivity** how fast heat passes through	**About 23 times as fast.** A warm body loses heat far faster in water.	Dense, oiled feathers trap a layer of air, which conducts heat poorly.	Wet fur traps no air, so thick **blubber** under the skin keeps its heat in.
S **Specific heat capacity** energy to warm 1 g by 1 °C	**About 4 times as high.** Water warms and cools slowly, so it is a stable habitat.	Its lake changes temperature only slowly, from day to night and from week to week.	The sea under the ice stays near −1.8 °C all year. The air above swings from −30 °C to above 0 °C.

Values at 20 °C. In an exam, either the common name or the scientific name is accepted.

Remember the four: *Big Vessels Turn Slowly*

A1.1.7 HIGHER LEVEL

Where Earth's water *came from*

- **Origin: asteroids** carrying water struck the young Earth. This is the one hypothesis you need.

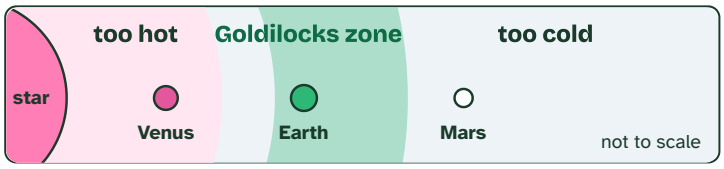
KEPT BY 1
Gravity
Earth is massive enough to hold on to its water.

KEPT BY 2
Temperature
Low enough for water vapour to condense into liquid oceans.

- Water has been abundant for billions of years, which gave **life the time to evolve**.
- **Evidence:** water in some meteorites has almost the same ratio of heavy to light hydrogen as the oceans.

A1.1.8 HIGHER LEVEL

The search for life *elsewhere*



- All known life needs liquid water, so the search for extraterrestrial life **looks for liquid water** first.
- The **Goldilocks zone** is the range of distances from a star where a planet's surface could keep water liquid.
- In the zone, water **could** be liquid. That does not show there is water, or life.

WATCH OUT

Six mistakes that *cost marks*

- ✕ **Hydrogen bonds are between molecules.** The O–H bonds inside a molecule are covalent.
- ✕ **Write δ+ and δ−, never a bare + or −.** Water is neutral.
- ✕ **Cohesion is water to water; adhesion is water to something else.** Capillary action needs both.
- ✕ **Capillary action does not lift water up a tree.** Evaporation from leaves pulls; cohesion holds the column.
- ✕ **Conductivity is not heat capacity.** One is how fast heat passes through water; the other, how much energy warms it.
- ✕ **Hydrophilic does not always mean soluble.** Cellulose attracts water but does not dissolve.

COVER THE SHEET

Can you *answer these?*

1. State why water is called the medium for life.
2. Draw two water molecules joined by a hydrogen bond.
3. Explain how water reaches the top of a tall tree.
4. Outline capillary action and two places it matters.
5. Name three solutes in blood plasma, and one molecule that is useful because it is hydrophobic.
6. Explain why a ringed seal needs blubber in the sea.
7. State two reasons why Earth kept its water. HL
8. Explain why the search for life looks in a star's Goldilocks zone. HL

IN THE EXAM

Name the bond ("hydrogen bonds between water molecules"), then **link the property to its consequence** for the organism.

GO FURTHER

Animated figures, a dry lab and a marked Check are in the full guide online.