DP Biology – A1.1

Water

- Which features of water make life possible?
- What does living in water make easier and harder for organisms?

SL statements A1.1.1–6. Textbook pp. 2–10.
Image: Earth from Apollo 17. NASA, public domain.



Objectives for each class

Class	Statements	By the end of the class, you can...
1	A1.1.1–4	Explain how polar covalent bonds lead to hydrogen bonds, and why cohesion and adhesion matter to organisms
2	A1.1.5–6	Explain why water is a good solvent, and compare the physical properties of water and air

Overview of this chapter

Part	Statements	What it covers
The medium for life	A1.1.1	Where the first cells arose, and where life happens
Bonds	A1.1.2	Polar covalent bonds and hydrogen bonds
Sticking together	A1.1.3–4	Cohesion and adhesion
Dissolving	A1.1.5	Metabolism, transport and hydrophobic molecules
Living in water	A1.1.6	Buoyancy, viscosity, conductivity, specific heat

Water is the medium for life

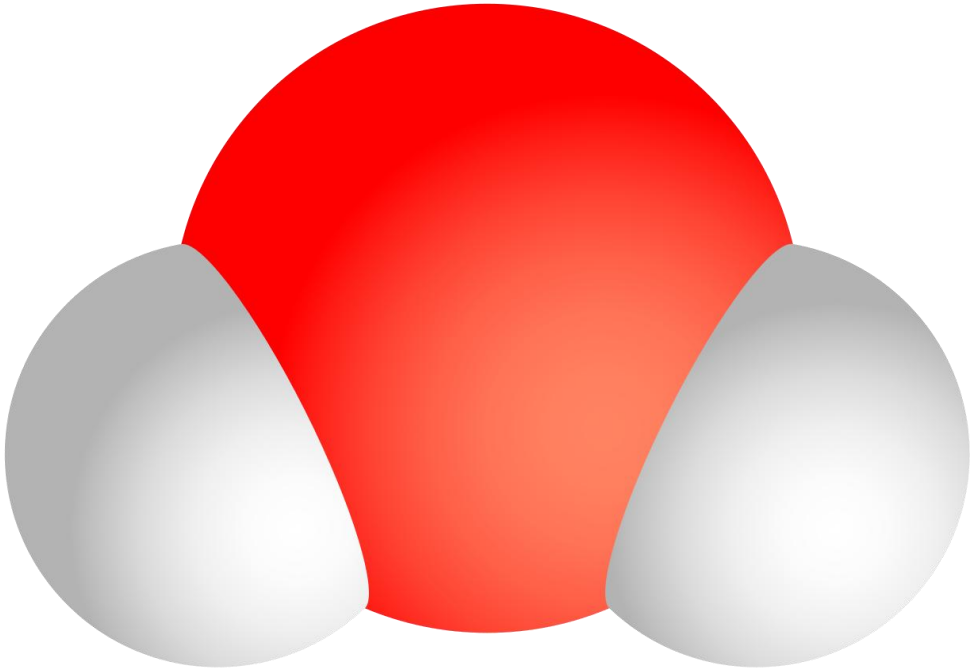
A1.1.1

- The **first cells** arose in water, enclosing a small volume of it inside a membrane
- Most of the processes of life still happen in water
- Water makes up much of the cytoplasm, and of organelles
- It also surrounds cells as tissue fluid, and it is the main part of blood plasma

Discussion

Over 70% of the surface of Earth is water. When astronomers search for life elsewhere, why do they begin by searching for water? Give a reason based on what cells do.

Polar covalent bonds in water



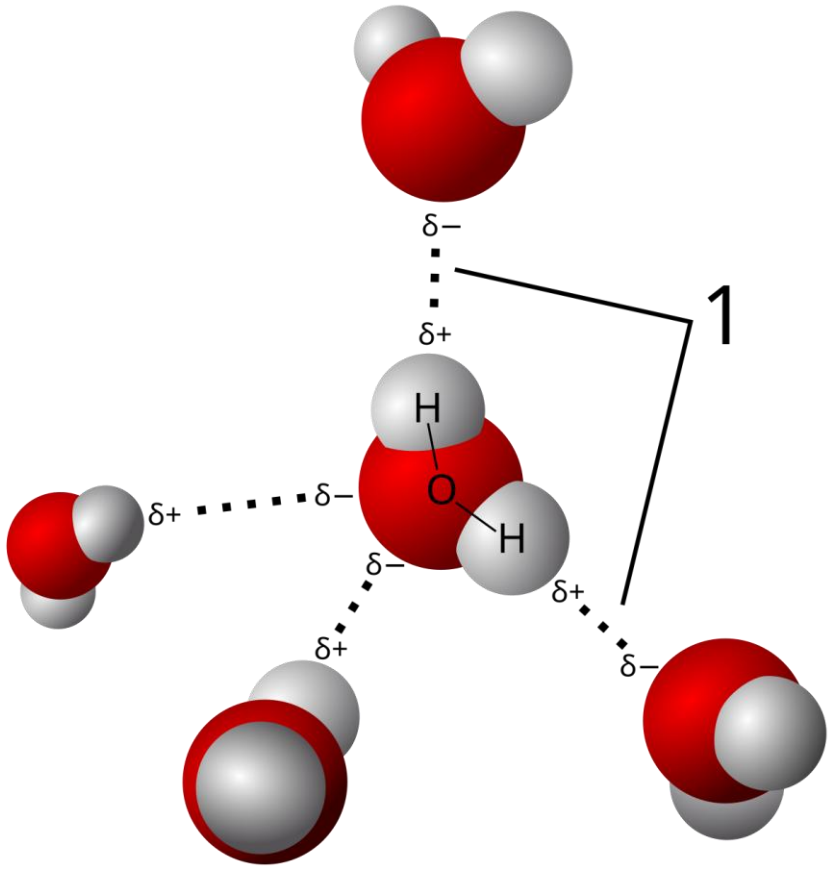
A water molecule. Sakurambo, public domain.

- Oxygen and hydrogen share electrons in **covalent bonds**
- Sharing is **unequal**: the oxygen nucleus attracts electrons more strongly
- So oxygen has a slight negative charge, and hydrogen a slight positive charge
- A molecule with charged ends like this is **polar**

Notation

Show the slight charges with the Greek letter delta. Write delta+ beside each hydrogen atom, and delta- beside the oxygen atom.

Hydrogen bonds between water molecules



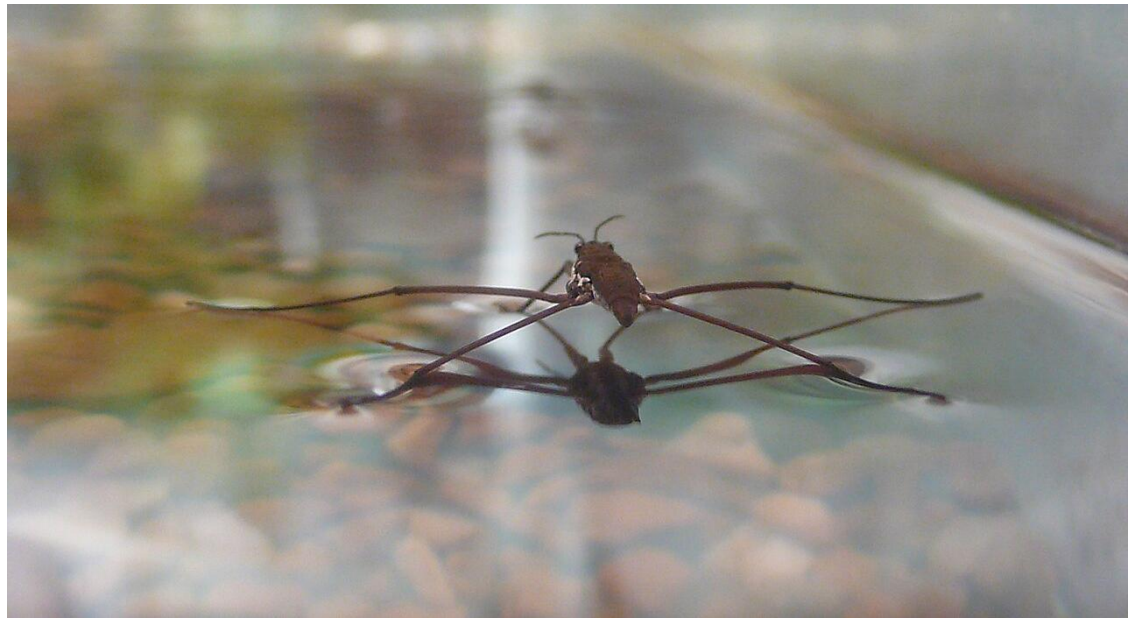
Hydrogen bonds in water. Qwerter, public domain.

- The slightly positive hydrogen of one molecule attracts the slightly negative oxygen of another
- This weak attraction is a **hydrogen bond**
- One hydrogen bond is weak, but there are very many in water
- Taken together, they give water its unusual properties

Activity

Draw three water molecules with hydrogen bonds between them. Show polarity with delta signs, and use dashed lines for hydrogen bonds.

Cohesion and its consequences



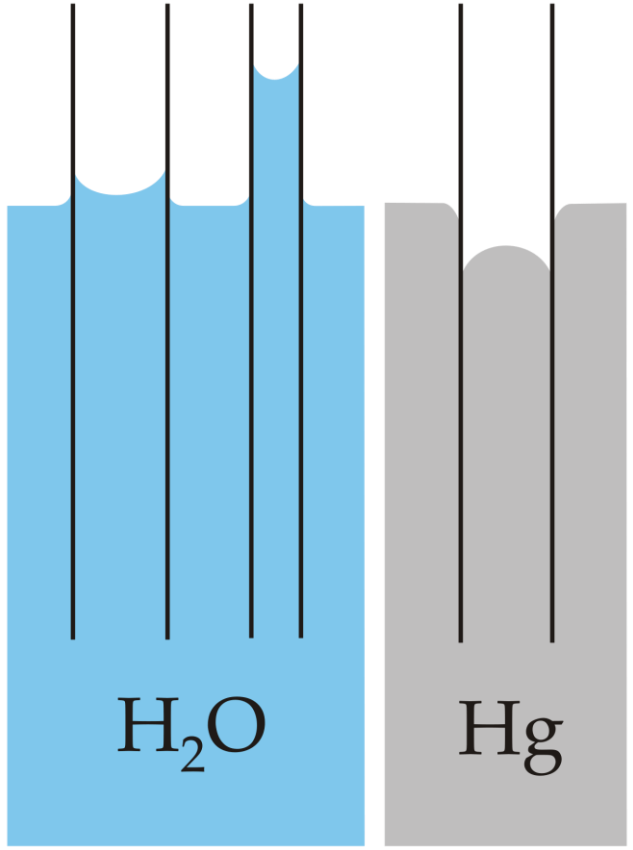
A water strider standing on a water surface. TimVickers, public domain.

- **Cohesion**: water molecules stick to one another, because of hydrogen bonds
- This resists a pulling force, which gives **surface tension**

Consequence	How cohesion is involved
Water under tension in xylem	Cohesion keeps the column of water intact as it is pulled up from the roots
Water surfaces as habitats	Surface tension can support small animals such as water striders

Adhesion and its consequences

A1.1.4



Capillary action in narrow tubes. MesserWoland, CC BY-SA 3.0.

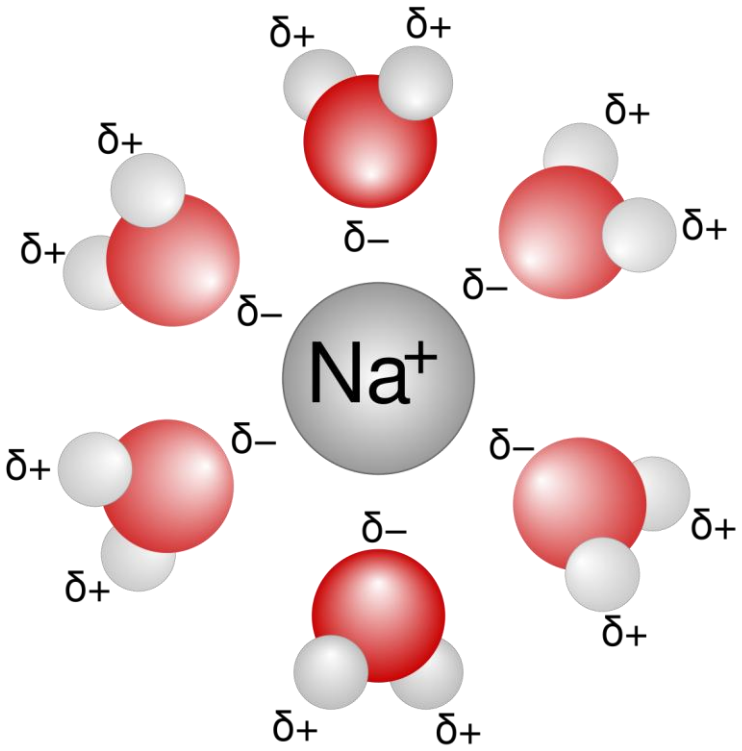
- **Adhesion**: water is attracted to polar or charged materials
- It forms hydrogen bonds with surfaces such as cellulose or clay
- Adhesion and cohesion together cause **capillary action**

Location	What it does
Soil	Draws water up from below, through narrow channels between particles, to roots
Plant cell walls	Draws water through cellulose fibres, so leaf cells stay moist

Common mistake

Cohesion is between water molecules. Adhesion is between water and something else. Say which one you mean.

Water as a solvent



Water surrounding a sodium ion. Steven P. Berg, public domain.

- Polar water molecules are attracted to ions and to other polar molecules
- They form shells around them, so they dissolve
- Substances that dissolve in this way are **hydrophilic**
- Most enzymes catalyse reactions in **aqueous solution**

Why it matters

Metabolism takes place in solution, where substrates can collide with enzymes. Water in blood, xylem and phloem transports dissolved substances around the organism.

Transport in blood depends on solubility

A1.1.5

Substance	Solubility	How it is carried
Glucose	Soluble	Dissolved in plasma: polar -OH groups form hydrogen bonds with water
Sodium chloride	Soluble	Dissolved in plasma as ions
Amino acids	Mostly soluble	Dissolved in plasma: all are soluble enough
Oxygen	Poorly soluble	Mostly bound to haemoglobin in red blood cells
Fats and cholesterol	Insoluble	Inside lipoprotein particles

Link

Lipoproteins are coated in phospholipids, with their hydrophilic heads facing the plasma.

When being insoluble is useful

A1.1.5



Water droplets on a waxy leaf. Siddharth Patil, CC0.

- **Hydrophobic** molecules are non-polar and do not dissolve in water
- The function of some molecules depends on this
- The hydrophobic core of a **membrane** forms a barrier
- Lipids store energy without affecting water balance
- Waxy leaf cuticles reduce water loss

Common mistake

Hydrophobic molecules are not repelled by water. They are simply less attracted to water than water molecules are to each other, so they are pushed together.

Physical properties: water compared with air

A1.1.6

Property	Meaning	Water	Air
Buoyancy	Upward force on an object	High	Low
Viscosity	Resistance to flow	High, causing more drag	Low
Thermal conductivity	Rate at which heat passes through	High, so heat is lost fast	Low, so air insulates
Specific heat	Energy to raise temperature	High, so temperature is stable	Low, so temperature changes fast

Key idea

Hydrogen bonds cause the high specific heat: energy is needed to break them before molecules move faster.

Consequences for animals in water

A1.1.6

Property	Challenge or opportunity	Example of an adaptation
Buoyancy	Water supports the body; staying down or up uses energy	Swim bladders in fish, and adjustable air in loons
Viscosity	Moving through water causes drag	Streamlined body shapes
Thermal conductivity	Warm-blooded animals lose heat fast	Blubber in seals; dense feathers in loons
Specific heat	Temperature stays stable, which gives a stable habitat	Many species tolerate only a narrow range

Two animals in water and air

A1.1.6



Ringed seal pup. Shawn Dahle, NOAA, public domain.



Black-throated loon. Robert Bergman, public domain.

	Ringed seal (Pusa hispida)	Black-throated loon (Gavia arctica)
Buoyancy	Fat is less dense, so it floats	Dense bones, and air sacs that it can compress to dive
Viscosity	Streamlined shape; flippers	Torpedo shape; webbed feet
Heat loss	Thick blubber	Dense, oiled feathers

Key idea

Each must also cope with air, where buoyancy and viscosity are low, and the loon must fly.

Check that you can explain

1. Why water is the medium for life
2. How polarity leads to hydrogen bonds
3. How to draw and label hydrogen bonds
4. Cohesion: xylem and surface tension
5. Adhesion: soil and cell walls
6. Solubility and transport in blood
7. Why being hydrophobic can be useful
8. Four physical properties, with examples

Exit activity: 5 minutes

On your own and without notes. Hand this in as you leave.

1. Explain why water molecules are polar.
2. Distinguish between cohesion and adhesion, giving one example of each in organisms.
3. Explain why a seal needs a thick layer of blubber in cold water.

Image credits

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Water molecule.svg – Sakurambo – Public domain

3D model hydrogen bonds in water.svg – User Qwerter at Czech wikipedia: Qwerter. Transferred from c – Public domain

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