Why water is strange

60 minutes • 1.1.A • Chapters 1, 2, 3, 4

Polarity and hydrogen bonds, then cohesion, adhesion and solvent, seen in demos and a circus of quick practicals

BY THE END, STUDENTS CAN

- [ ] Explain how unequal sharing of electrons makes water polar, and draw hydrogen bonds between water molecules with partial charges 1.1.A
- [ ] Explain how cohesion gives water its surface tension and lets transpiration pull a column of water up the xylem 1.1.A
- [ ] Explain how adhesion to polar surfaces, with cohesion, moves water by capillary action 1.1.A
- [ ] Explain why ions and polar molecules dissolve in water while nonpolar ones do not, and why that matters to a cell 1.1.A
- [ ] Explain water's high specific heat, evaporative cooling and floating ice in terms of hydrogen bonds 1.1.A

TIMING

0–5	5 min	**Do now: one wet hand**	
5–15	10 min	**A lopsided molecule**	
15–23	8 min	**Build and bond**	
23–48	25 min	**Properties of water circus**	
48–55	7 min	**Pull it together**	
55–60	5 min	**Exit**	
	60 min	**One lesson**	

STARTER

5 min

Do now: one wet hand

Students wet the back of one hand, keep the other dry, and blow on both. Pairs write what they feel and one idea for why. Keep the ideas for the end of the lesson.

ON THE BOARD, FROM THE GUIDE

Open the guide on the projector at each chapter (the links work in this PDF). Every figure plays from its own buttons, and the lesson's slides have the same figures, step by step, in the order of this plan.

01 One lopsided molecule, and the bonds it makes

CHAPTER 01 IN THE SLIDES

Step through the figure (6 steps, the arrow keys on a projector). Stop on each caption and ask what changed before you go on.

1. One water molecule: an oxygen with two hydrogens, **bent**, with about 104.5° between the bonds.
2. The shared **electrons** (the pink cloud) crowd round the oxygen and thin out round each hydrogen.
3. So the oxygen is slightly negative and each hydrogen slightly positive: **partial** charges, not whole ones.
4. A second molecule turns its oxygen to face a hydrogen of the first, and a dashed line joins them: a **hydrogen bond**.
5. One molecule can make up to **four**: two through its hydrogens and two to its oxygen.
6. The notation the exam wants: letters, solid lines for covalent bonds, dashed lines for hydrogen bonds, and δ signs. **Draw it like this**.

Step through the figure (3 steps, the arrow keys on a projector). Stop on each caption and ask what changed before you go on.

1. Each water molecule is **polar**: the oxygen is slightly negative and the hydrogens slightly positive.
2. A slightly positive hydrogen is attracted to the oxygen of another molecule: a **hydrogen bond**.
3. Each bond lasts only a moment. They **break and form** all the time as the molecules move; in liquid water most molecules are held by several at once.

> **Predict box:** Water boils at 100 °C. Methane, CH_4, a molecule of about the same size, is nonpolar and boils at about −160 °C. What explains the difference? Hands up or mini whiteboards first.
>
> **Answer B: Water molecules are held to one another by hydrogen bonds, which must be broken before they can leave as a gas**

> **Remember it:** Cats Always Skip Hot Showers (Cohesion, Adhesion, Solvent, Heat, Surface tension).

02 Water holds on to itself

CHAPTER 02 IN THE SLIDES

Step through the figure (5 steps, the arrow keys on a projector). Stop on each caption and ask what changed before you go on.

1. A pond skater stands on water. Its long legs spread its weight, and each foot makes a small **dimple** in the surface.
2. Inside the water, each molecule is pulled by its neighbors equally in **every direction**, so it stays where it is.
3. At the surface there are no neighbors above: the pull is **sideways and inwards**, and the surface holds together like a stretched film. That is **surface tension**.
4. Close up, water-repellent **hairs** on the foot press the film into a dimple without breaking it, and the film pushes back up.
5. A mosquito **larva** hangs from the underside of the film and breathes through a tube that pokes through it.

Play the animation, Watch it happen: pulling water up a stem. It loops; pause it on each moment below and ask what is happening (in the lesson slides it is a video).

1. Water **evaporates** from the wet cell walls in the leaf and escapes through a stoma.
2. Each molecule that leaves pulls on the next: **hydrogen bonds** hold the column together.
3. The whole column is pulled up from the roots, under **tension**.

> **Predict box:** Ground pepper floats on a bowl of water. You touch the middle of the surface with a finger dipped in dish soap. What does the pepper do? Hands up or mini whiteboards first.
>
> **Answer A: It shoots out to the edge of the bowl, pulled by the surface that is still clean all around**

03 Water clings to other surfaces

CHAPTER 03 IN THE SLIDES

Step through the figure (5 steps, the arrow keys on a projector). Stop on each caption and ask what changed before you go on.

1. Water is attracted to the polar glass wall and forms bonds with it: **adhesion**. The water's edge curves up where it meets the glass.
2. **Cohesion** drags more water up behind the edge, and the column rises until its weight balances the pull.
3. The **narrower** the tube, the higher the water climbs.
4. Wax has nothing for water to cling to: with no adhesion the surface curves down and sits **below** the level outside.
5. The same pull holds water between **soil** particles and soaks it through the gaps in a **cellulose** cell wall.

> **Predict box:** Three cups in a row: red water, an empty cup, blue water. A strip of paper towel bridges each full cup and the empty one. What is in the middle cup a few hours later? Hands up or mini whiteboards first.
>
> **Answer C: Purple water, because water creeps along the paper from both sides and the colors mix**

> **Remember it:** Copies Anything (Cohesion, Adhesion).

04 The solvent a cell runs in

CHAPTER 04 IN THE SLIDES

Step through the figure (5 steps, the arrow keys on a projector). Stop on each caption and ask what changed before you go on.

1. A grain of salt is a lattice of **ions**, sodium (Na^+) and chloride (Cl^-), held together by their opposite charges.
2. Water molecules turn to face the ions, **oxygen** toward Na^+ and **hydrogens** toward Cl^-, and together they pull ions loose.
3. Dissolved: every ion is wrapped in its own **shell** of water molecules and drifts away from the rest.
4. A sugar is covered in OH groups, which make **hydrogen bonds** with water, so it dissolves too.
5. Oil molecules are **nonpolar**. Water bonds to water, not to oil, so the oil is pushed together into a droplet.

Show the figure: Ten substances sorted: five dissolve in water and five do not. The five that do not are useful because of it: wax keeps water in the leaf, fat stores energy and insulates, cholesterol is part of membranes, cellulose makes cell walls that must not dissolve, and calcium phosphate makes bones that last.

> **Predict box:** Fish take all their oxygen from water, and oxygen molecules (O_2) are nonpolar. How does the oxygen get into the water? Hands up or mini whiteboards first.
>
> **Answer B: Small nonpolar molecules dissolve a little, and a little is enough for fish with large gills**

THE LESSON

10 min

A lopsided molecule

Chapter 1's figure a step at a time: the bent molecule, the shared electrons, the partial charges, the hydrogen bond. Ask before step 4: "If one end is slightly negative and the other slightly positive, what happens when two molecules meet?" Then chapter 1's predict box (water against methane).

8 min

Build and bond

Model water molecules (activity below): pairs build three, join them with hydrogen bonds and label every partial charge. Check the drawings: solid lines inside a molecule, dashed between.

25 min

Properties of water circus

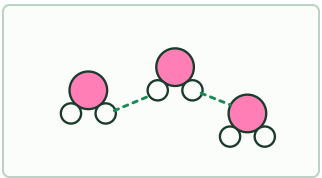
Four stations, about 6 minutes each (activity below): drops on a coin, the paper towel bridge, dissolve or not, and pepper and soap. At each, students predict, do, and write which property and which bond explain it. Chapter 2's and chapter 3's predict boxes are two of the stations.

7 min

Pull it together

The Remember it tiles in chapter 1, then chapter 2's film on the board: switch on the air bubble and ask why the water below it stops. Students add cohesion and adhesion to their circus sheet in one sentence each.

ACTIVITIES

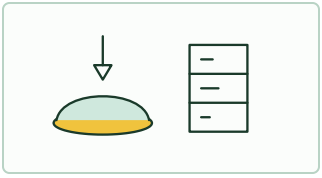


MODEL

Build and bond water

Pairs build three water molecules from a molecular model kit (or modeling clay and toothpicks), set at the bent angle. They join them with string or pipe cleaners for hydrogen bonds, always hydrogen to oxygen, then label every δ+ and δ− on sticky notes. Last, they draw the same three molecules in their notes with solid and dashed lines.

Needs: a molecular model kit per pair (or modeling clay in two colors and toothpicks), string or pipe cleaners, small sticky notes.

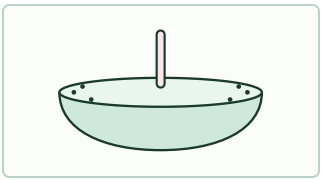


PRACTICAL

Properties of water circus

Four stations. **Drops on a coin:** count how many drops of water fit on a coin before it spills, then repeat with soapy water. **Paper towel bridge:** two colored cups and an empty one joined by paper strips (chapter 3's predict box). **Dissolve or not:** salt, sugar, oil and sand in water. **Pepper and soap:** pepper on water, touched with a soapy finger (chapter 2's predict box). At each, students predict, observe, name the property and explain it with hydrogen bonds.

Needs: coins, droppers, dish soap, clear cups, food coloring, paper towel strips, salt, sugar, cooking oil, sand, ground pepper, a shallow bowl, paper towels for spills.



DEMO

Pepper and soap

Sprinkle ground pepper over a shallow bowl of water, then touch the middle with a fingertip dipped in dish soap. The pepper races to the edge. Run it as chapter 2's predict box: students commit to an answer first, then explain it with surface tension.

Needs: a shallow white bowl, water, ground black pepper, dish soap. Change the water between runs: one drop of soap ruins the next demo.

PLENARY

5 min

Exit

Back to the wet hand: why did it feel colder? Students answer in two sentences using "hydrogen bonds" and "energy." Chapter 4's predict box (oxygen in water) for anyone who finishes.

WHAT STUDENTS GET WRONG

"A hydrogen bond is the O–H bond in a water molecule." That bond is covalent. A hydrogen bond is between molecules. Make students point to one on chapter 1's figure.

"Water is a universal solvent, so it dissolves everything." Oil, wax and cellulose do not dissolve, and cells depend on that. Use the dissolve or not station.

"Cohesion and adhesion are the same." Cohesion is water to water; adhesion is water to something else that is polar or charged. Capillary action needs both.

STRETCH AND SUPPORT

Stretch: explain why ethanol has a lower surface tension than water, using the hydrogen bonds each molecule can make.

Support: a sentence frame for each property: "Water ____ because its molecules ____, which happens because ____."

Support: a pre-drawn water molecule to label with δ+, δ− and a dashed bond, before drawing from memory.

For revision: students can drill this unit's key terms on Cramly.

IN THE GUIDE

1 One lopsided molecule, and the bonds it makes

2 Water holds on to itself

3 Water clings to other surfaces

4 The solvent a cell runs in

All The whole guide, with the figures that play

PPTX This lesson's slides, in the order of this plan

EXAM PRACTICE

Check yourself

Set it for homework: a fresh paper of exam-bank questions on 1.1 and 1.2 each time, marked as students go and saved to their Exam practice when they are signed in.

biologybybradford.com/exam-maker/sit?program=ap&units=U1&ced=1.1,1.2&paper=quiz&marks=15&src=ep

PRACTISE AND REVISE

BUILD FOR YOUR CLASS

- Tarsia puzzle, dominoes and picture reveal on Unit 1, built from its key terms and ready to print
- A pub quiz with rounds on Unit 1, to present or run with no projector
- The Frozen Lake Station escape room, or an escape room built from the question bank on Unit 1

ALREADY ON THE SITE FOR UNIT 1

- Lesson: Water & Elements of Life
- Quiz: Water & Elements of Life
- Exam questions: Unit 1 in the exam maker, a paper with scoring guidelines

CARD SETS ON SPLYCR

Open a set to host it as a class game, or make a copy to edit.

- Unit 1: Chemistry of Life (part 1)
- Unit 1: Chemistry of Life (part 2)

How this was made. The course structure, the activities and the teaching choices come from my own classroom, my presentations and my years of teaching IB and AP Biology. I use Claude, an AI, to help write and build the interactive guides, lesson plans, slides and practice questions, and to draw the diagrams and code the interactives. I direct the work and review it against the IB and AP specifications before it goes live.