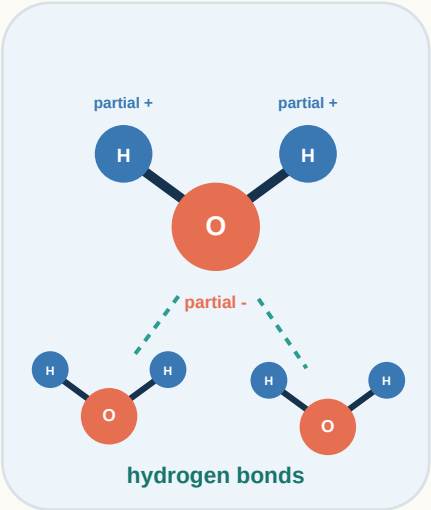
AP BIOLOGY | UNIT 1

TOPIC 1.1

Structure of Water and Hydrogen Bonding

A tiny imbalance of charge explains why water can stabilize temperature, move through plants, dissolve solutes, and support life.



THE CORE CAUSAL CHAIN

POLAR uneven charge → **H-BONDS** between molecules → **PROPERTIES** emergent behavior → **LIFE** stable aqueous systems

BY THE END, YOU SHOULD BE ABLE TO...

1. Explain why water is polar from electronegativity and molecular shape.
2. Distinguish polar covalent bonds from hydrogen bonds.
3. Link hydrogen bonding to water's biologically important properties.

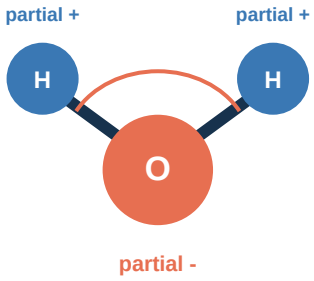
BIG IDEA

The structure of water determines its function. Polar water molecules form many hydrogen bonds, and the combined effect of those bonds produces properties that organisms depend on.

1 From shape to polarity

Start at the molecular level, then build outward to interactions between molecules.

ONE WATER MOLECULE



104.5 degree bent shape

WHY POLAR?

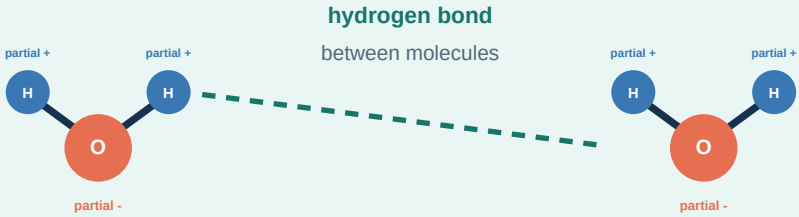
1. **Electronegativity:** oxygen attracts the shared electrons more strongly than hydrogen.
2. **Partial charges:** oxygen becomes partially negative; each hydrogen becomes partially positive.
3. **Bent shape:** the bond dipoles do not cancel, so the whole molecule has a net polarity.

STRUCTURE -> FUNCTION

Polarity makes water interact with ions, polar molecules, and other water molecules.

HYDROGEN BONDING

The partial positive hydrogen of one molecule is attracted to the partial negative oxygen of a different molecule.



BOND CHECK

Location	Interaction	Meaning
Within one H2O	**Polar covalent bond**	Shared electron pair; relatively strong.
Between H2O molecules	**Hydrogen bond**	Electrostatic attraction; weak alone, powerful in large numbers.

COMMON ERROR

Do not label the O-H bond inside water as a hydrogen bond. It is a polar covalent bond.

2 Properties that support life

For full-credit explanations, name the molecular cause and then the biological consequence.

COHESION

Mechanism

Hydrogen bonds attract water molecules to one another.

Biological consequence

Water stays in continuous columns. During transpiration, water leaving a leaf helps pull more water upward through xylem.

ADHESION

Mechanism

Polar water molecules are attracted to other polar or charged surfaces.

Biological consequence

Water clings to xylem walls. Together with cohesion, this helps resist gravity during water transport.

SURFACE TENSION

Mechanism

Surface water molecules form a cohesive hydrogen-bonded network.

Biological consequence

The surface resists disruption, producing a skin-like effect that can support small organisms such as water striders.

HIGH SPECIFIC HEAT

Mechanism

Much absorbed energy first disrupts hydrogen bonds before molecular motion increases substantially.

Biological consequence

Water changes temperature slowly, buffering aquatic habitats and helping organisms maintain stable internal conditions.

VERSATILE SOLVENT

Mechanism

Partial charges surround ions and interact with other polar solutes, forming hydration shells.

Biological consequence

Ions, sugars, amino acids, and many reactants can dissolve and move in cytoplasm, blood, and other aqueous solutions.

ICE IS LESS DENSE

Mechanism

A stable hydrogen-bonded lattice spaces water molecules farther apart than in liquid water.

Biological consequence

Ice floats and insulates the liquid below, allowing aquatic ecosystems to persist in cold conditions.

MEMORY SHORTCUT

Cohesion = water to water. Adhesion = water to another surface. Both begin with water's polarity.