AP BIOLOGY | UNIT 1 | TOPICS 1.1 AND 1.2

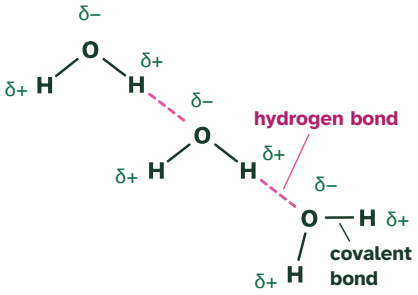
REVISION ON TWO PAGES

Water, carbon and *life*

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

THE ONE IDEA

Water is polar, so it forms hydrogen bonds: every property follows. Life builds its molecules on carbon, from six elements.



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

1.1.A START HERE

Polar bonds make *hydrogen bonds*

- Oxygen is more **electronegative** than hydrogen: it pulls the shared electrons toward itself. This **unequal sharing** makes each O–H bond a **polar covalent bond**, with a slightly negative oxygen (δ–) and slightly positive hydrogens (δ+).
- The δ+ hydrogen of one molecule is attracted to the δ– oxygen of a neighbor. That attraction is a **hydrogen bond**: it holds **one molecule to the next**, and is about 20 times weaker than a covalent bond.
- One hydrogen bond is weak and brief, but each molecule can make up to four, and there are vast numbers of them. Breaking them takes energy.

WHAT HYDROGEN BONDS GIVE WATER

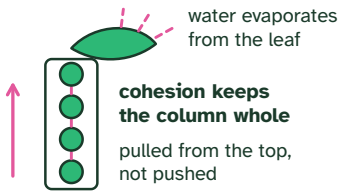
Cats Always Skip Hot Showers

C	**Cohesion**	water sticks to water
A	**Adhesion**	water sticks to polar surfaces
S	**Solvent**	dissolves ions and polar molecules
H	**Heat**	slow to warm and to cool
S	**Surface tension**	a film at the surface

1.1.A WATER TO WATER

Cohesion

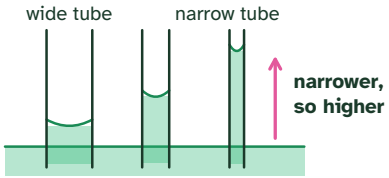
- **Cohesion**: hydrogen bonds hold water molecules to one another.
- **At a surface:** molecules have no neighbors above, so they are pulled sideways and inward. The surface acts like a stretched film: **surface tension**. A water strider stands on it.
- **In xylem: transpiration** from leaves pulls on the molecules behind, so a whole column is drawn up. No pump is needed.



1.1.A WATER TO OTHER THINGS

Adhesion

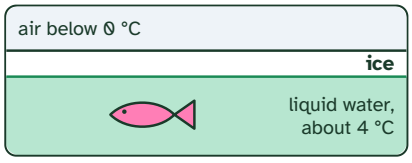
- **Adhesion**: water is attracted to surfaces that are **polar or charged**, such as glass, cellulose and soil particles.
- **Capillary action**: water adheres to the walls of a narrow space and climbs; cohesion drags the rest behind.
- It soaks water through soil and cell walls. On **nonpolar** wax, water beads up and runs off.



1.1.A THREE EFFECTS, ONE CAUSE

Water and *heat*

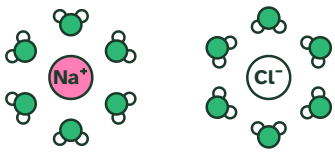
- **High specific heat**: energy breaks hydrogen bonds before molecules speed up, so water warms and cools slowly. Seas and cells hold a steady temperature.
- **Evaporative cooling**: the fastest molecules escape and take their energy with them. Sweat and transpiration cool this way.
- **Ice floats**: frozen molecules lock into four hydrogen bonds in an open lattice, so ice is less dense than liquid water.



1.1.A

The *solvent* a cell runs in

- **Ions dissolve:** the δ– oxygens of water turn toward positive ions and the δ+ hydrogens toward negative ions, and each ion leaves **wrapped in a shell of water**.
- **Polar molecules dissolve:** sugars and amino acids **form hydrogen bonds with water**.
- **Why it matters:** cytoplasm is a water solution where enzymes and their substrates meet; blood and xylem carry dissolved substances.



Oxygens face the positive ion; hydrogens face the negative ion

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

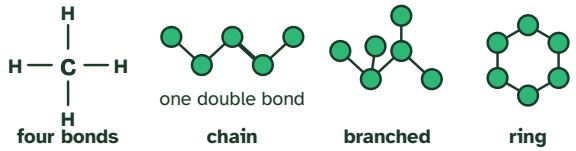
Hydrophobic nonpolar
Wax keeps water in a leaf. **Fat** stores energy. The nonpolar middle of a **membrane** keeps a cell's contents in.

Carbon skeletons and the *six elements* of life

1.2.A

Why life is built on *carbon*

- The molecules of life are **organic molecules**: carbon skeletons with other atoms attached.
- A carbon atom has four electrons to share, so it forms **four covalent bonds**. A double bond uses two of the four.
- Carbon bonds strongly to carbon, building **chains, branches and rings**. Shape decides what a molecule can do.



1.2.A FOUR TO KNOW

Functional groups

- A **functional group** is a small group of atoms on the skeleton that decides how the molecule reacts.

–OH **Hydroxyl** Polar: sugars dissolve.	–COOH **Carboxyl** Acidic: amino and fatty acids.
–NH_2 **Amino** Brings in nitrogen.	–PO_4 **Phosphate** Brings in phosphorus.

1.2.A LEARN THE PATTERN

Which *elements* are in which molecule

CLASS	ALWAYS CONTAINS	ALSO, IN SOME	SO THE ORGANISM NEEDS
Carbohydrates sugars, starch, cellulose	**C, H, O**	Nothing else.	Carbon, for every class and for every energy store.
Lipids fats, oils, phospholipids	**C, H, O**	**P** in phospholipids.	Phosphorus to build the phospholipids of every membrane.
Proteins chains of amino acids	**C, H, O, N**	**S** in some amino acids.	Nitrogen: every amino acid has an amino group.
Nucleic acids DNA and RNA	**C, H, O, N, P**	Nothing else.	Nitrogen for every base, and phosphorus for every nucleotide.

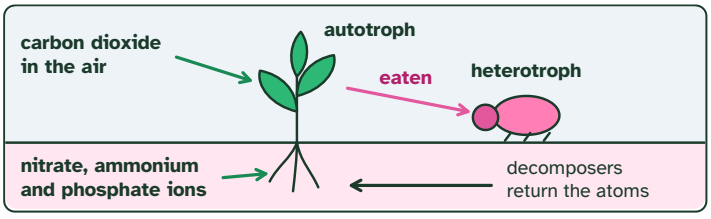
Six elements make up almost all the mass of a living thing.

Remember the six: *Cows Have Odd Names, Personally Speaking*

1.2.A

Where the atoms *come from*

- No organism makes its own atoms. To grow, repair and reproduce, it must **exchange matter with its environment**.
- A plant takes **carbon** as carbon dioxide from the air, and **nitrogen** and **phosphorus** as ions from the soil.
- An animal takes in all three by eating. Decomposers return them, so the atoms cycle.



WATCH OUT

Five mistakes that *cost points*

- ✕ **A hydrogen bond is between molecules.** The O–H bonds inside one molecule are covalent.
- ✕ **Write δ+ and δ–, never a bare + or –.** Water is neutral.
- ✕ **Water is pulled up a tree, not pushed.** Capillary action alone lifts it only a short way.
- ✕ **Sweat cools only as it evaporates.** On a humid day it drips off and cools very little.
- ✕ **A plant's mass comes mostly from the air.** Soil gives minerals; carbon dioxide gives the carbon.

COVER THE SHEET

Can you *answer these?*

1. Draw a hydrogen bond between two water molecules.
2. Explain how water reaches the top of a 100 m tree.
3. Describe capillary action and one place it matters.
4. Explain why salt dissolves in water but oil does not.
5. Explain why a lake warms more slowly than the air.
6. Predict what would happen to pond life if ice sank.
7. Describe why carbon can build so many molecules.
8. Identify two classes of molecule that need nitrogen.

IN THE EXAM

Name the bond, then the result: "hydrogen bonds between water molecules" earns the point, "water is sticky" does not. Then say what the property does for the organism.

GO FURTHER

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