

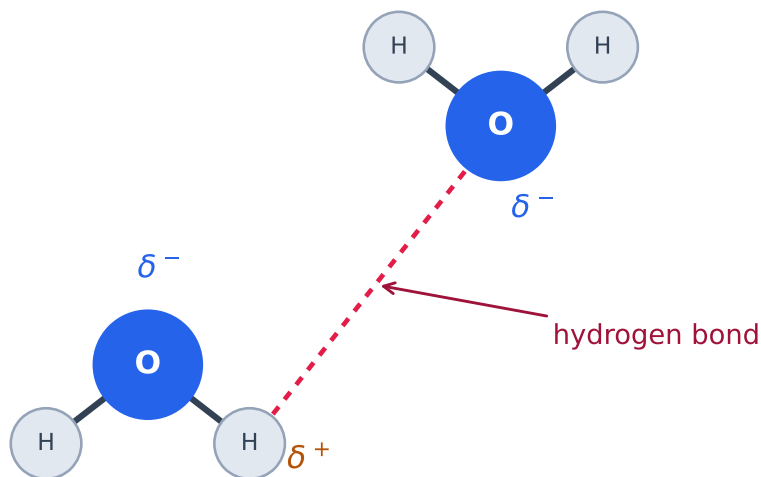
# Chemistry of Life

AP Biology

## Structure of Water and Hydrogen Bonding

Water is **polar** 极性: its oxygen pulls electrons more strongly than its hydrogens, giving a slightly negative O and slightly positive H. This lets water molecules form **hydrogen bonds** 氢键 with each other, which explains water's life-supporting properties:

- **Cohesion** 内聚力 and **adhesion** 附着力 (surface tension, capillary action, water rising in plants),
- high **specific heat** 比热容 (resists temperature change, stabilizing organisms),
- high heat of vaporization (evaporative cooling),
- ice floating (less dense solid), and being a great **solvent** for polar and ionic substances.



*A hydrogen bond between two polar water molecules*

## Elements of Life

Living matter is built mostly from a few elements –carbon, hydrogen, oxygen, nitrogen, phosphorus, and sulfur. **Carbon** 碳 is central because it forms four stable covalent bonds, building long chains, branches, and rings –the skeletons of all biological molecules.

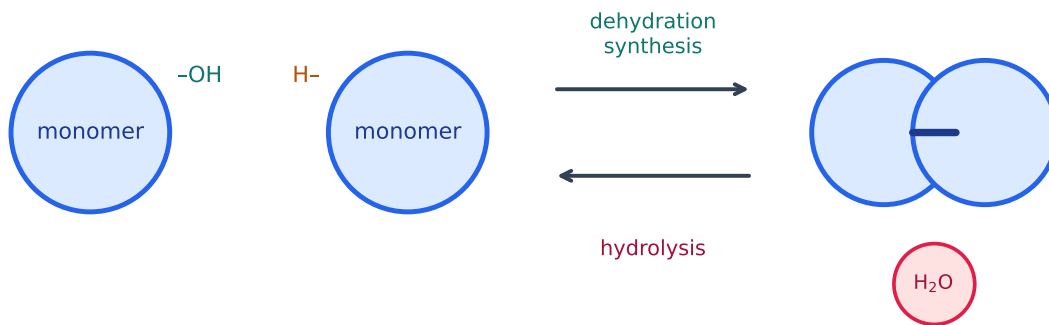
carbohydrates  
and fats  
C H O

proteins  
C H O N

*Carbohydrates and fats contain carbon, hydrogen, and oxygen; proteins also contain nitrogen*

## Introduction to Macromolecules

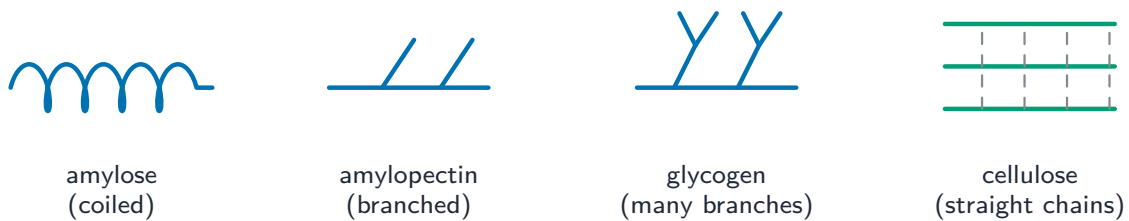
Large biological molecules –**macromolecules** 大分子—are **polymers** 聚合物 built from repeating **monomers** 单体. Cells join monomers by **dehydration synthesis** 脱水缩合 (removing water to form a bond) and break polymers by **hydrolysis** 水解 (adding water). Four classes: carbohydrates, lipids, nucleic acids, and proteins.



*Dehydration synthesis builds polymers and releases water; hydrolysis reverses it*

## Carbohydrates

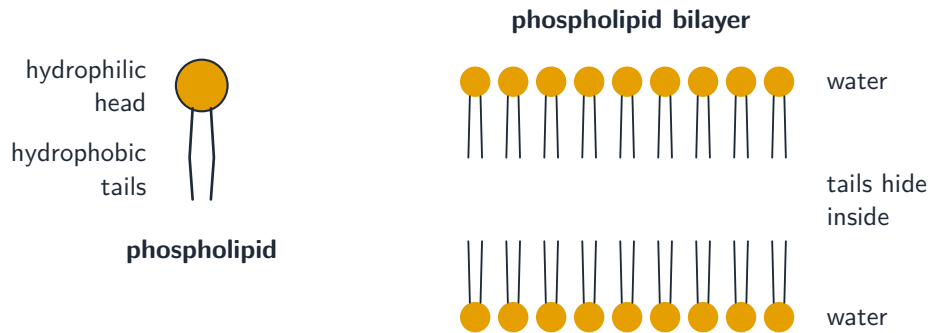
**Carbohydrates** 碳水化合物 are made of sugar monomers (**monosaccharides** 单糖 like glucose). They store energy (starch, glycogen) and provide structure (**cellulose** 纤维素 in plant walls). Their many hydroxyl groups make them polar and water-soluble.



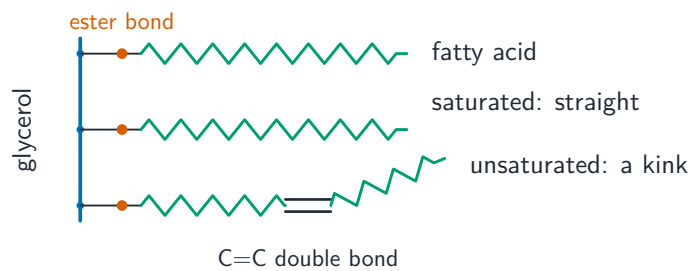
*The shapes of storage polysaccharides (starch, glycogen) and structural cellulose*

# Lipids

**Lipids** 脂质 are **nonpolar** and do not mix with water (**hydrophobic** 疏水). They include fats (long-term energy storage), **phospholipids** 磷脂 (which build membranes), and steroids. A phospholipid has a polar "head" and nonpolar "tails," the key to the cell membrane.



*A phospholipid has a polar head and two nonpolar tails, so phospholipids form a bilayer*



3 ester bonds form  $\rightarrow$  3 H<sub>2</sub>O removed (condensation)

*A triglyceride: glycerol joined to three fatty acids*

# Nucleic Acids

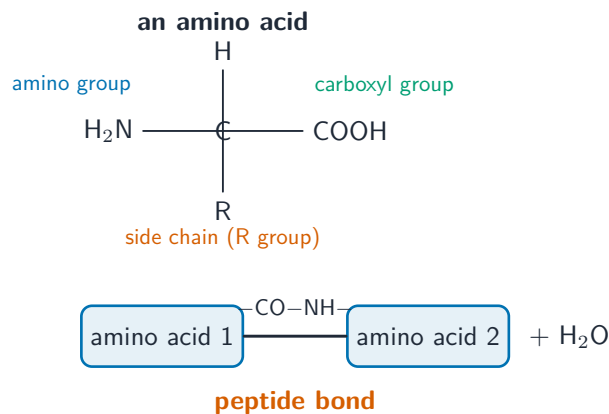
**Nucleic acids** 核酸 (DNA and RNA) store and carry genetic information. Their monomers are **nucleotides** 核苷酸, each a sugar, a phosphate, and a nitrogen base. The base sequence encodes instructions; DNA is double-stranded, RNA single-stranded.



*Complementary base pairing holds the two antiparallel strands of DNA together*

## Proteins

**Proteins** 蛋白质 are polymers of **amino acids** 氨基酸 joined by **peptide bonds** 肽键. Their sequence folds into a specific 3-D shape at four levels (primary, secondary, tertiary, quaternary), and **shape determines function** –as enzymes, transporters, receptors, and structural parts. Changing the environment (heat, pH) can **denature** 变性 a protein, unfolding it and stopping its function.



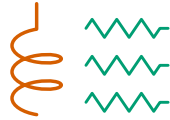
condensation removes one water for each peptide bond

*An amino acid, and the peptide bond formed by condensation*



**primary (1°)**

order of  
amino acids



**secondary (2°)**

$\alpha$ -helix &  $\beta$ -sheet  
(hydrogen bonds)



**tertiary (3°)**

folded into a  
precise 3-D shape



**quaternary (4°)**

two or more  
chains together

*The four levels of protein structure*

## Exam tips

- Trace every property of water back to its **polarity and hydrogen bonding** (cohesion, high specific heat, solvent power).
- Know the four macromolecule classes and their monomers; polymers are built by **dehydration synthesis** and broken by **hydrolysis**.
- For proteins, **structure (shape) determines function** —heat or a pH change **denatures** them and stops them working.
- In DNA the bases pair A–T and C–G on **antiparallel** strands; RNA is single-stranded and uses U.
- Link each molecule to its role (carbohydrates: energy/structure; lipids: membranes/storage; nucleic acids: information).