

A fluorescence micrograph showing numerous cells against a black background. The cells are stained with two different dyes: one that glows blue and another that glows red. The blue-stained cells are more numerous and appear as bright, irregular shapes. The red-stained cells are fewer and often show a distinct nucleus or internal structure. The overall effect is a vibrant, high-contrast image of biological structures.

Cells: The Units of Life

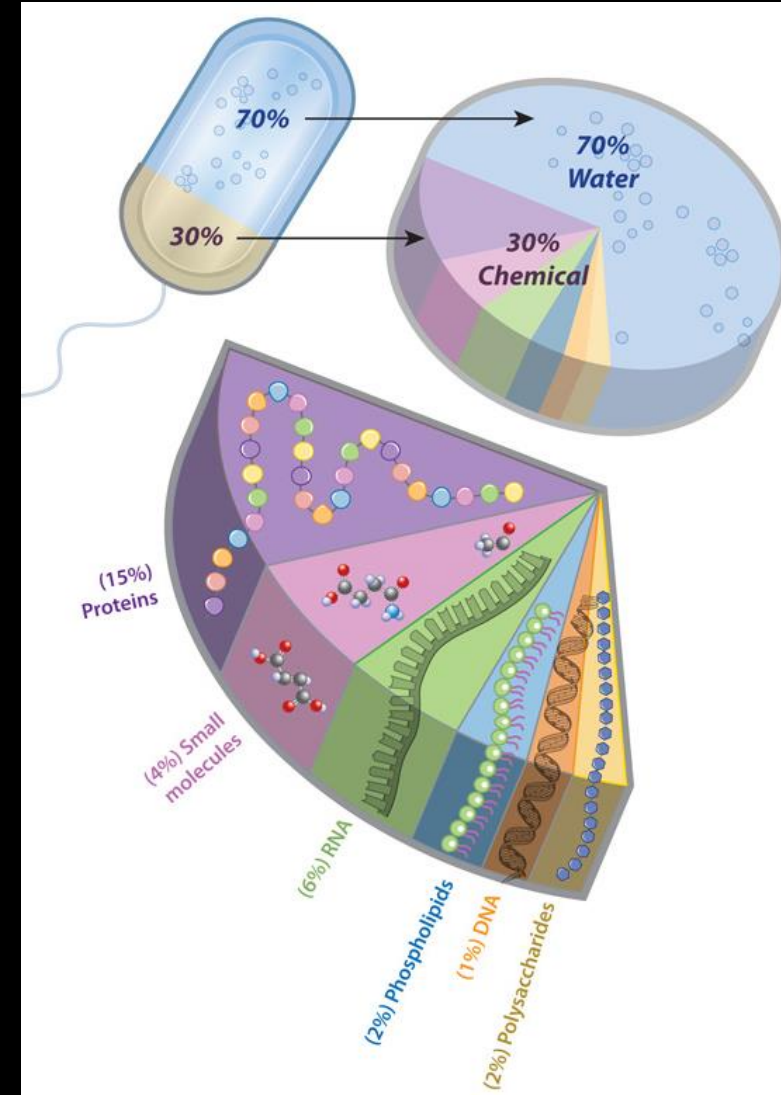
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Everything in physiology is about how cells survive, communicate, and work together.

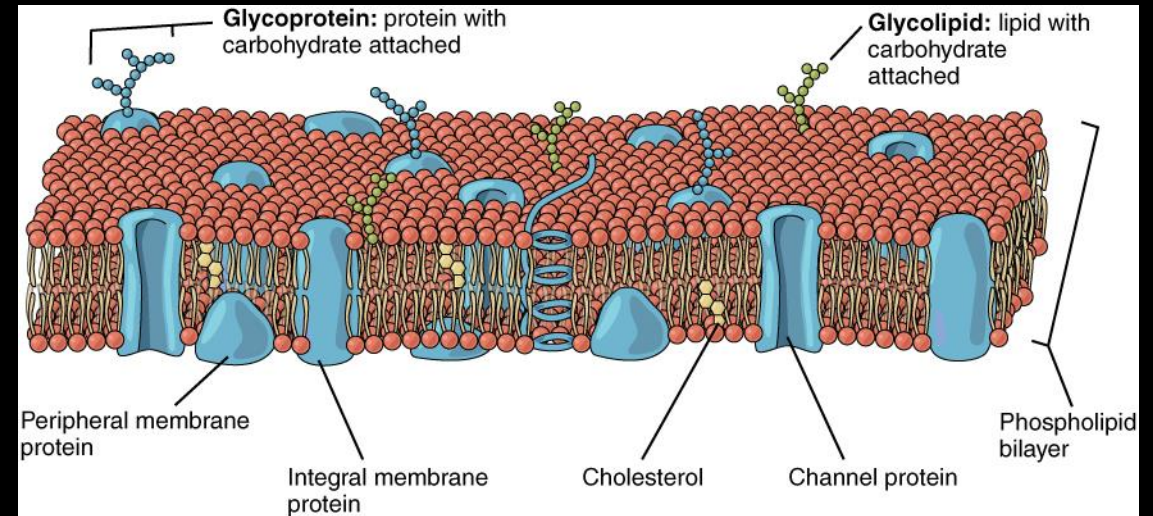
What is a cell?

- **Cell:** the basic structural and functional unit of all forms of life
- All organs are made of several types of specialized cells
- Every cell consists of cytoplasm and nucleic acids enclosed within a membrane
- Cells are 70% water



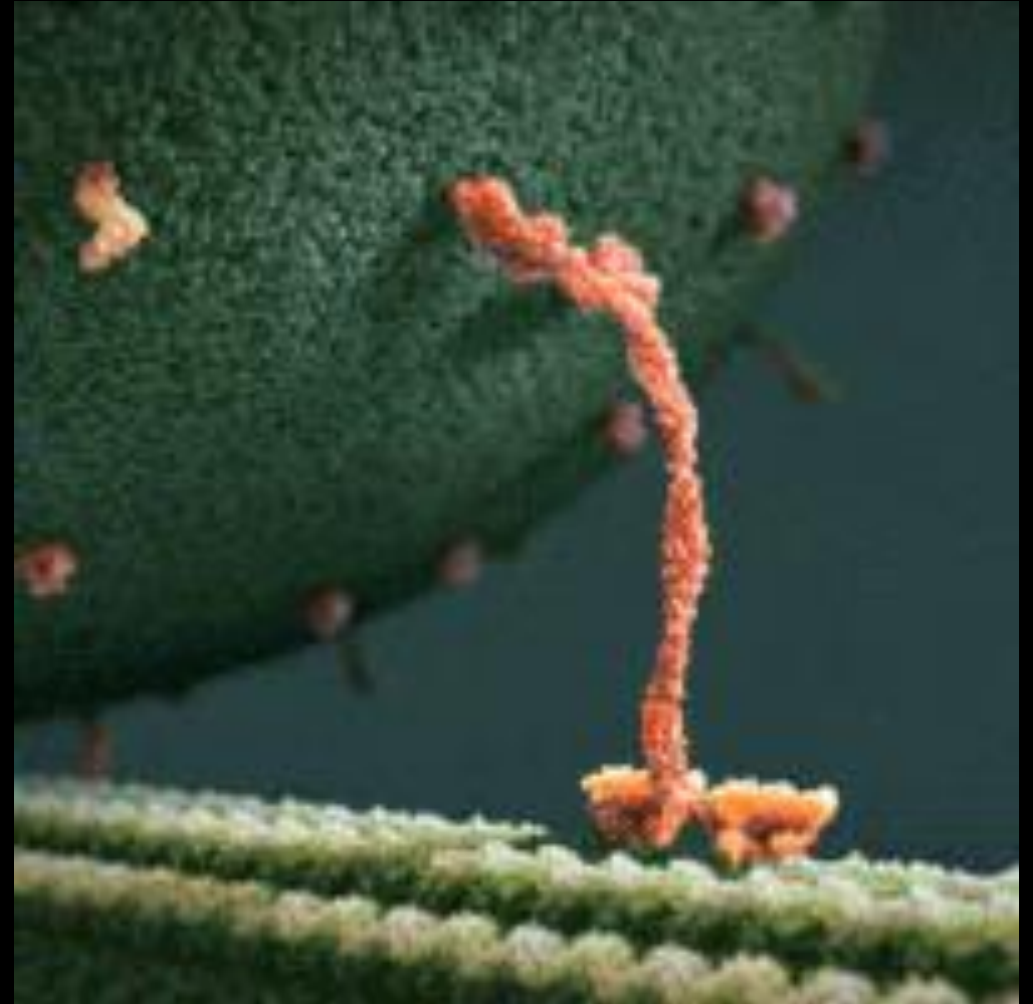
Cell membrane

- **Membrane:** a flexible “gatekeeper” made of fats/lipids and proteins
 - protects the cell and controls communication, nutrients, and waste exchange.
- Membranes exist around each cell and also surround each organelle, separating them from the rest of the cell



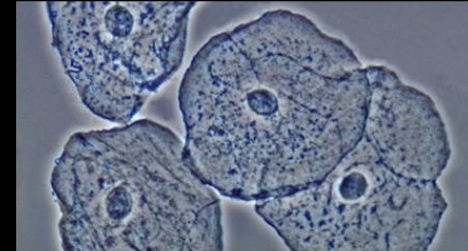
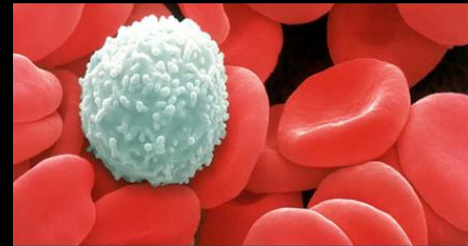
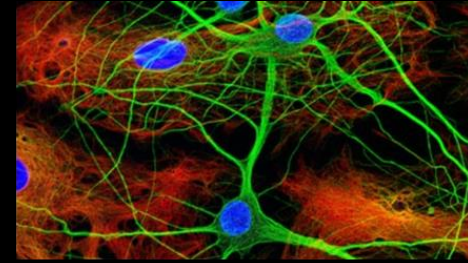
Cell function

- Cell function is mainly derived from the activities of proteins
- These activities require an ongoing source of energy
- Protein synthesis is the general process that uses DNA (instructions) to build proteins that carry out cellular functions



Cell differentiation

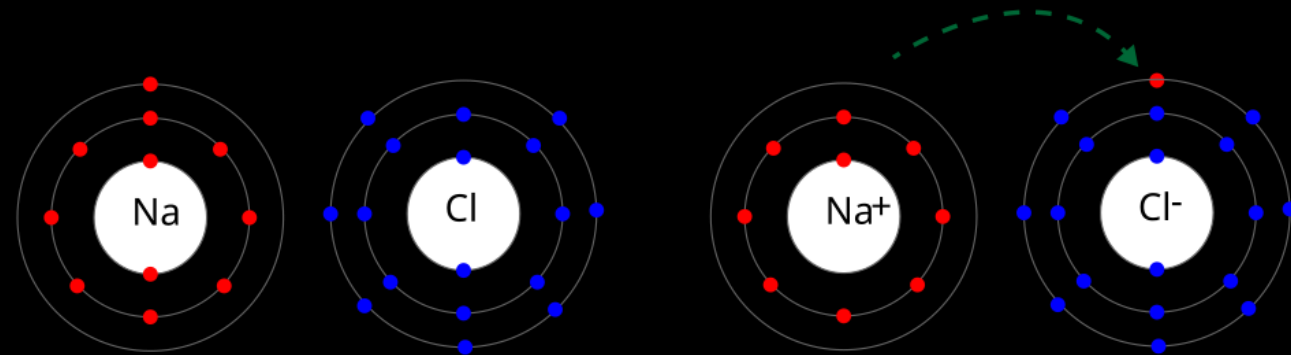
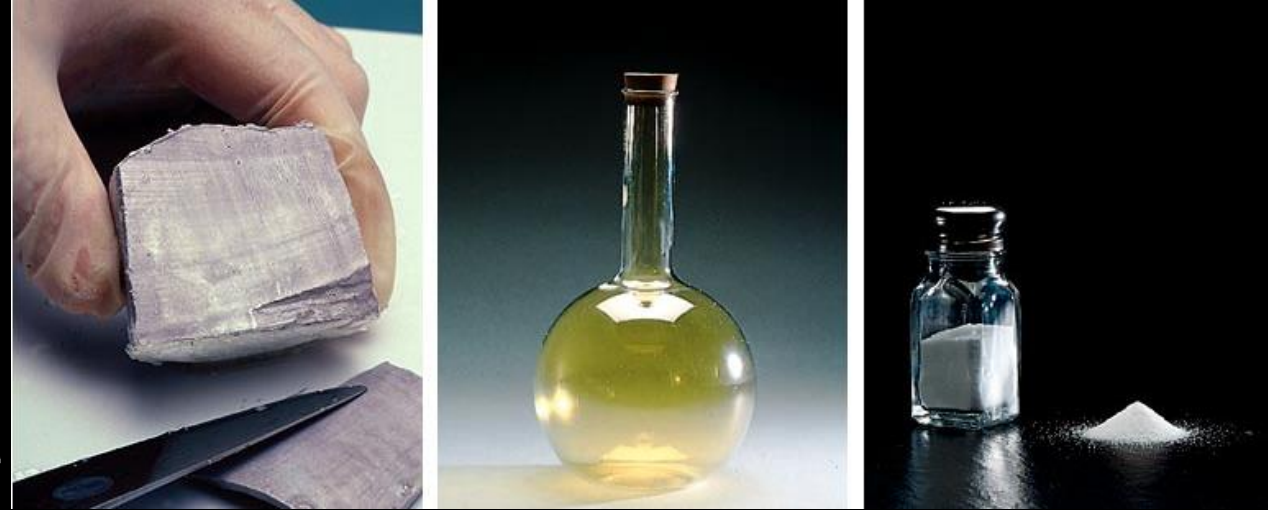
- Each cell in a single organism has the same DNA but not all of the genes are turned on at once, hence they have different proteins
 - e.g. In a neuron, the neuron genes are turned on so neuron proteins are made and all other genes (like blood, skin, etc.) are turned off



What are cells made of?

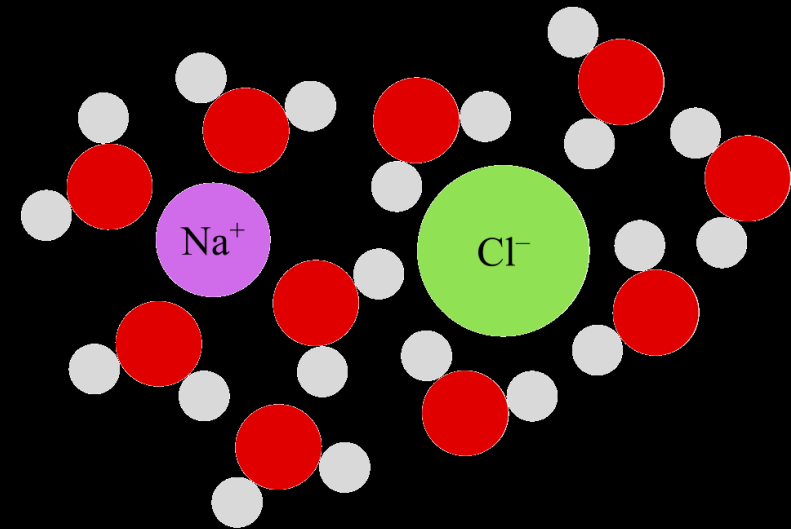
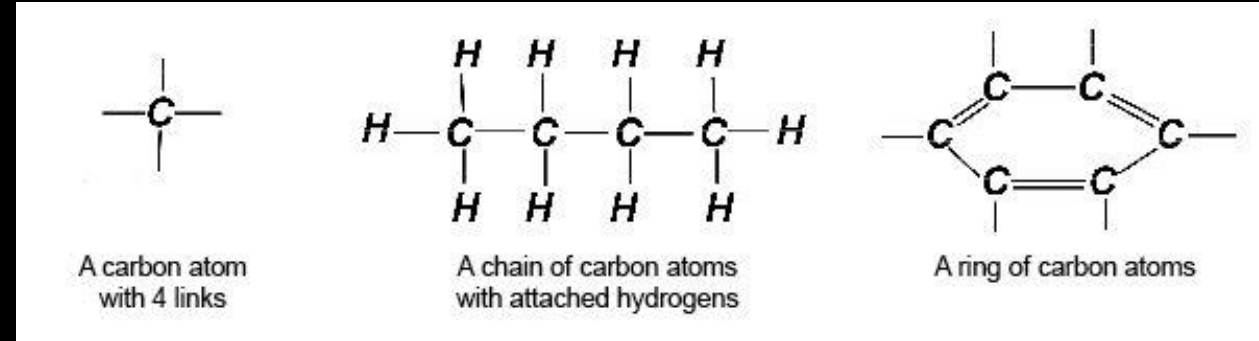
Molecules

- **Molecule:** any combination of two or more atoms (may be same atom)
 - **Emergent property:** a characteristic, behavior, or capability that a complex system possesses, but which its individual parts do not have on their own
 - Molecules can have characteristics that are different from either of the individual elements = emergent properties
- **Chemical reaction:** occurs when new bonds form or old bonds are broken
- **Reactants:** starting substances
- **Products:** ending substances



Inorganic vs. Organic Compounds

- **Organic compounds:** carbon-based molecules typically bonded to hydrogen, oxygen, or nitrogen, forming the basis of life (e.g., glucose, proteins)
- **Inorganic compounds:** generally lack carbon-hydrogen bonds, often consisting of metals, salts, and minerals (e.g., water, CO₂, NaCl)



Macromolecules overview

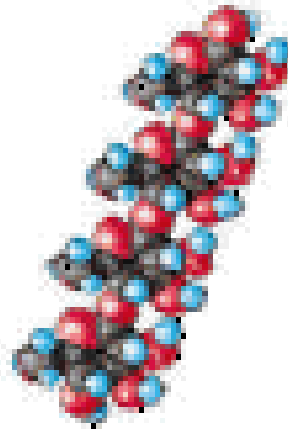
Proteins = cell functions

Lipids = barriers

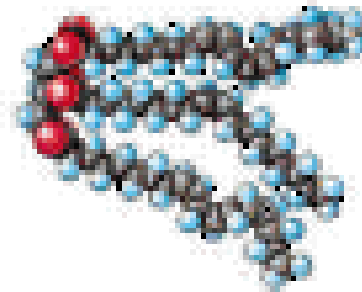
Carbohydrates = energy

Nucleic acids = instructions

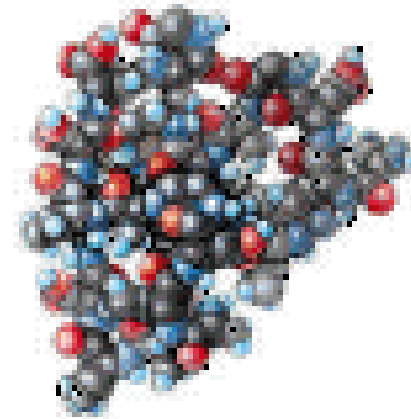
Biological Macromolecules



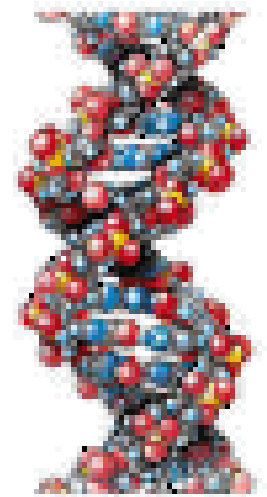
**Carbohydrate
(starch)**



**Lipid
(triacylglycerol)**



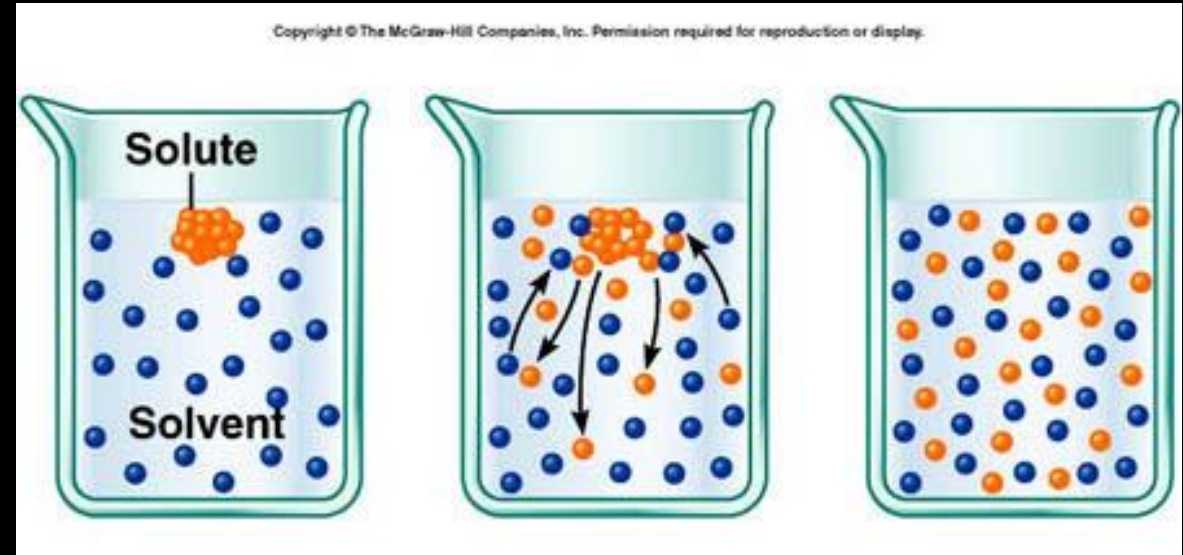
**Protein
(enzyme)**



**Nucleic acid
(DNA)**

Solutions

- **Solution:** a mixture of one or more solutes dissolved in a solvent
 - E.g. salt water
- **Solute:** the substance that dissolves to form a solution
 - E.g. salt
- **Solvent:** the substance in which a solute dissolves
 - E.g. water

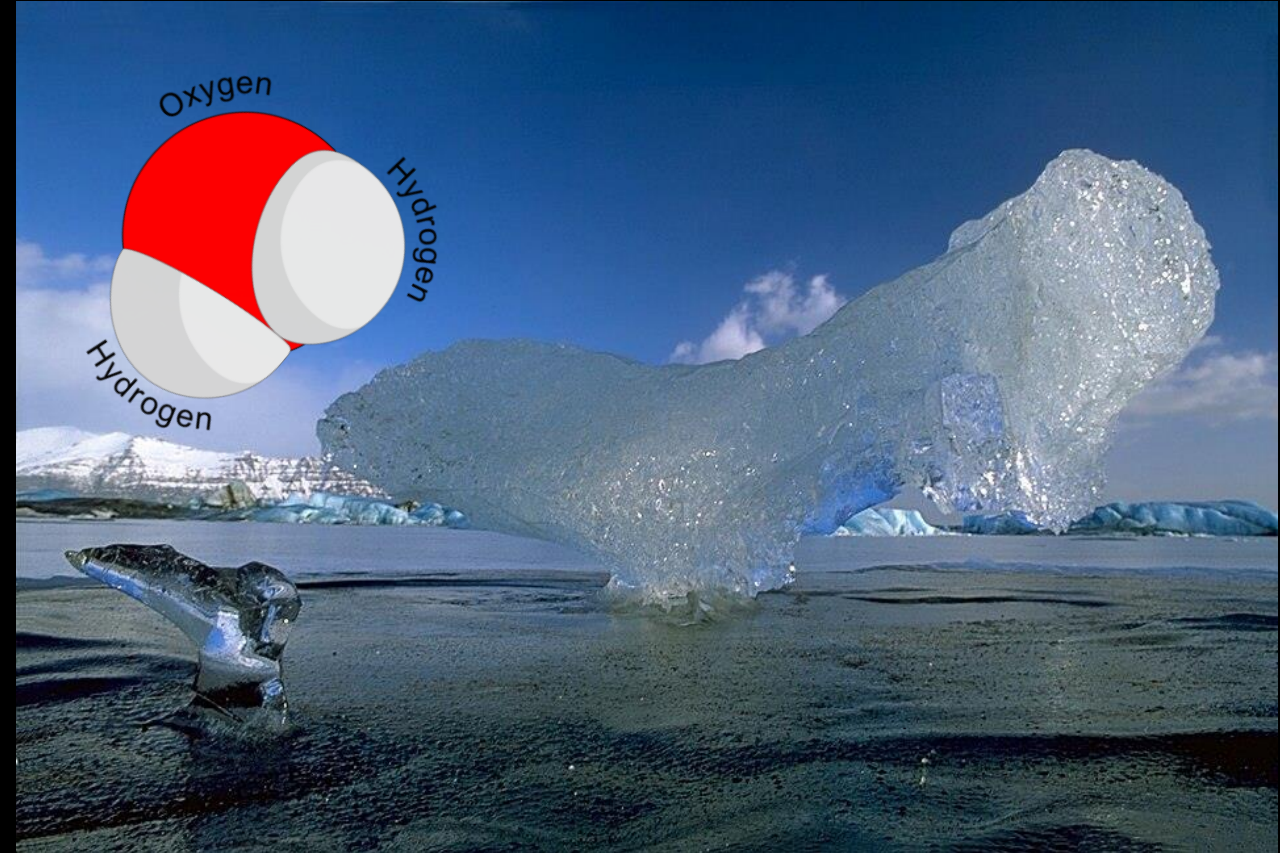


- **Hydrophilic solutes:** contain polar or charged bonds and easily dissolve in water
- **Hydrophobic solutes:** contain nonpolar bonds and do not dissolve in water

Why Water Matters to Cells

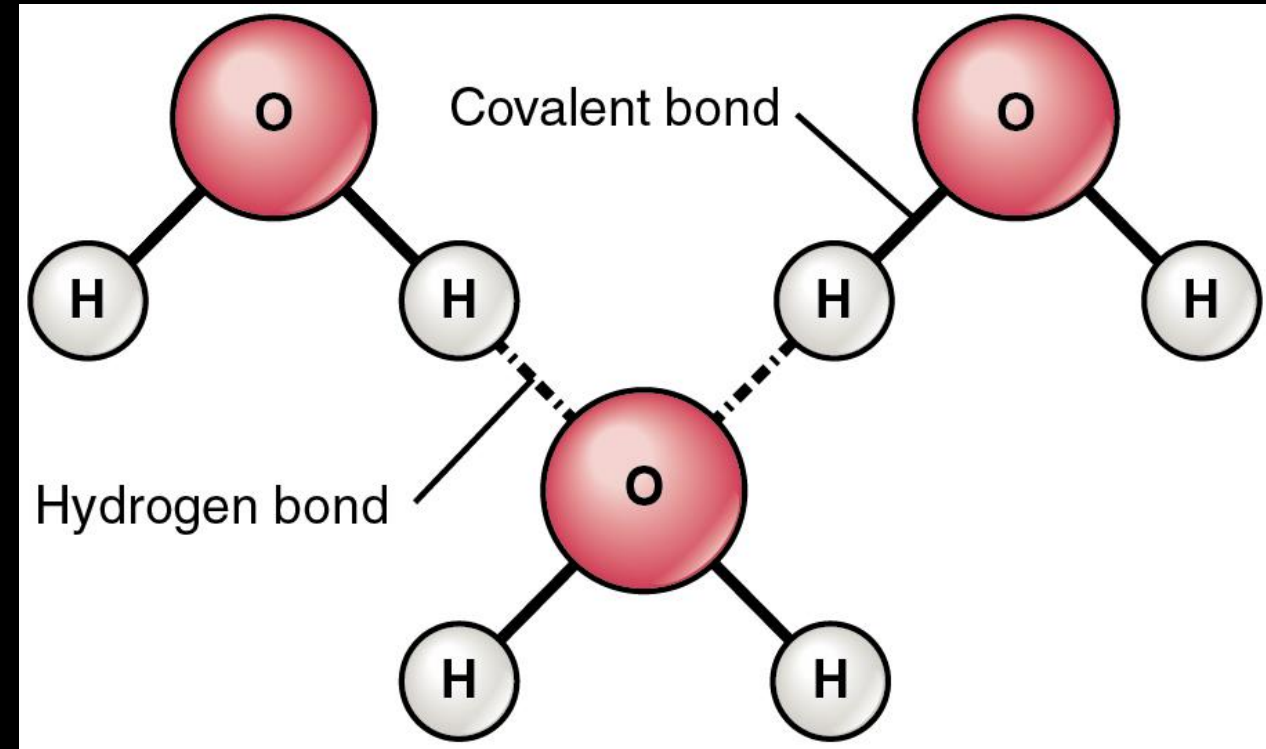
Water Chemistry

- Water is essential for all life on earth
- Water has special chemical properties that make it ideal for life
- Humans can survive ~3 days without water
- Chemical structure of water is H₂O



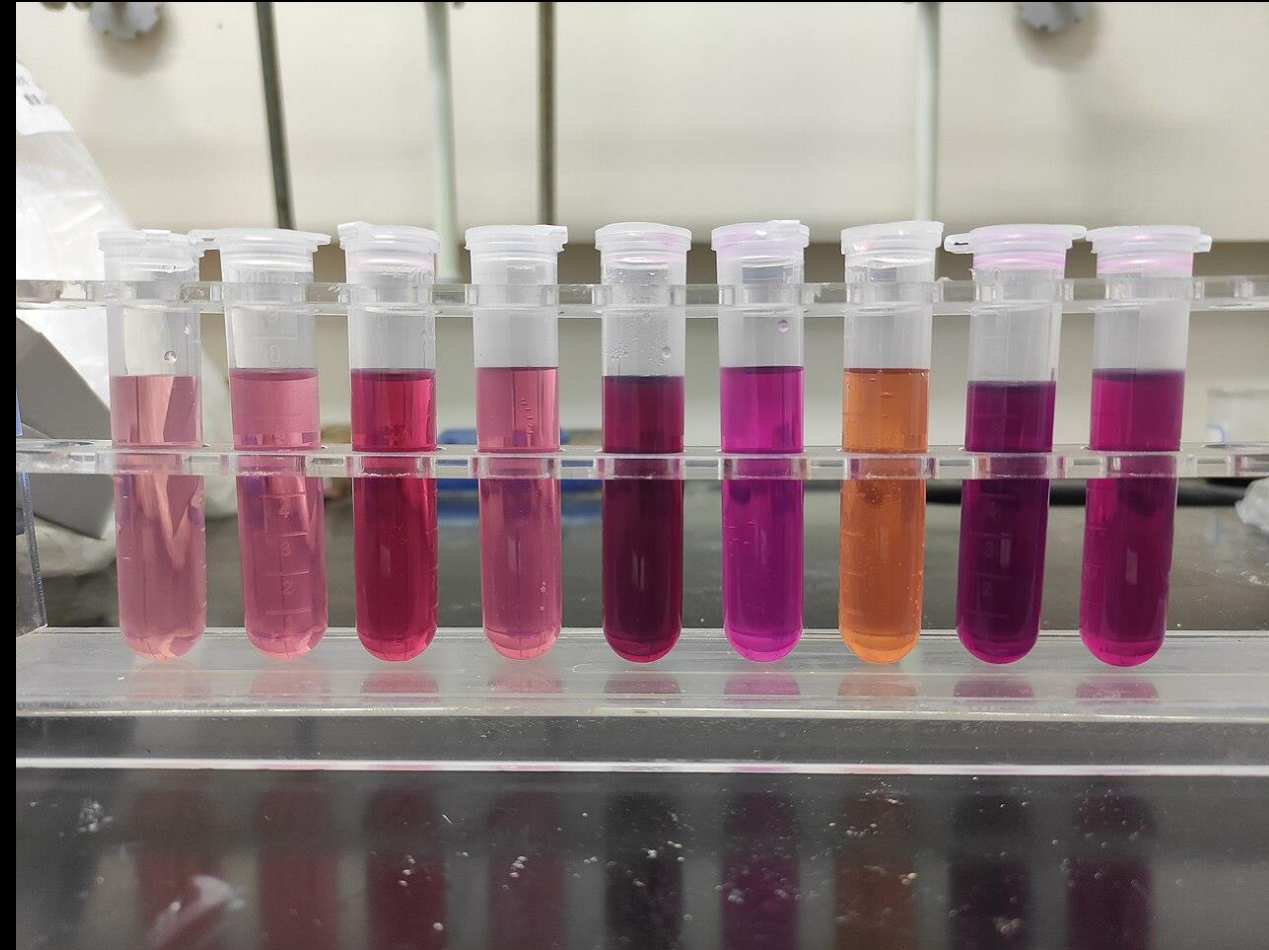
Hydrogen bonds

- In water, oxygen holds the electrons longer than hydrogen, this makes the oxygen slightly negative and the hydrogen slightly positive
- Because of the slight +/-, nearby water molecules adhere to each other like tiny magnets
- **Hydrogen bonds:** the weak attraction between a slightly positive molecule and a slightly negative part of another molecule
 - Drawn as dotted lines between molecules



Water properties

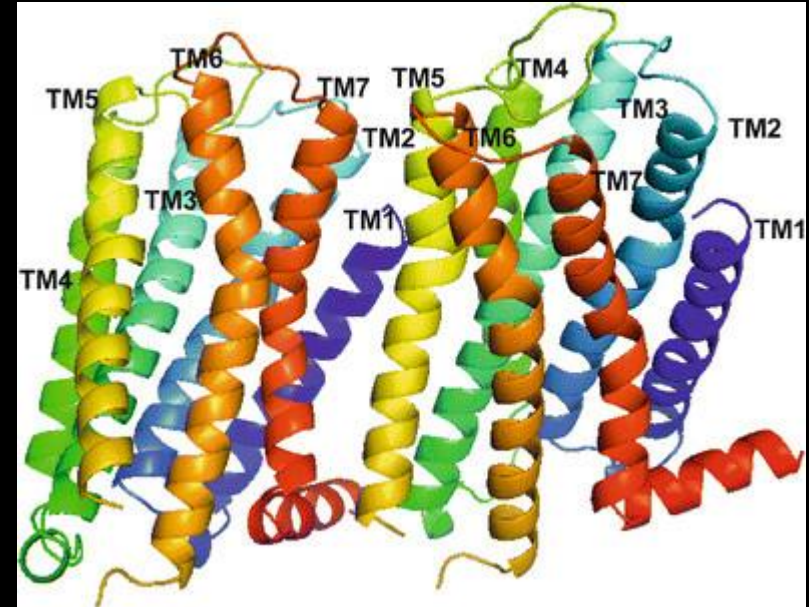
- Because of the hydrogen bonds water has several important properties:
- **High specific heat:** takes a large amount of energy to change the water temperature
 - Important for temperature homeostasis
- **Solvent properties:** many solutes can dissolve in water
 - Important for transport of nutrients, oxygen, and waste



How Cells Do Stuff

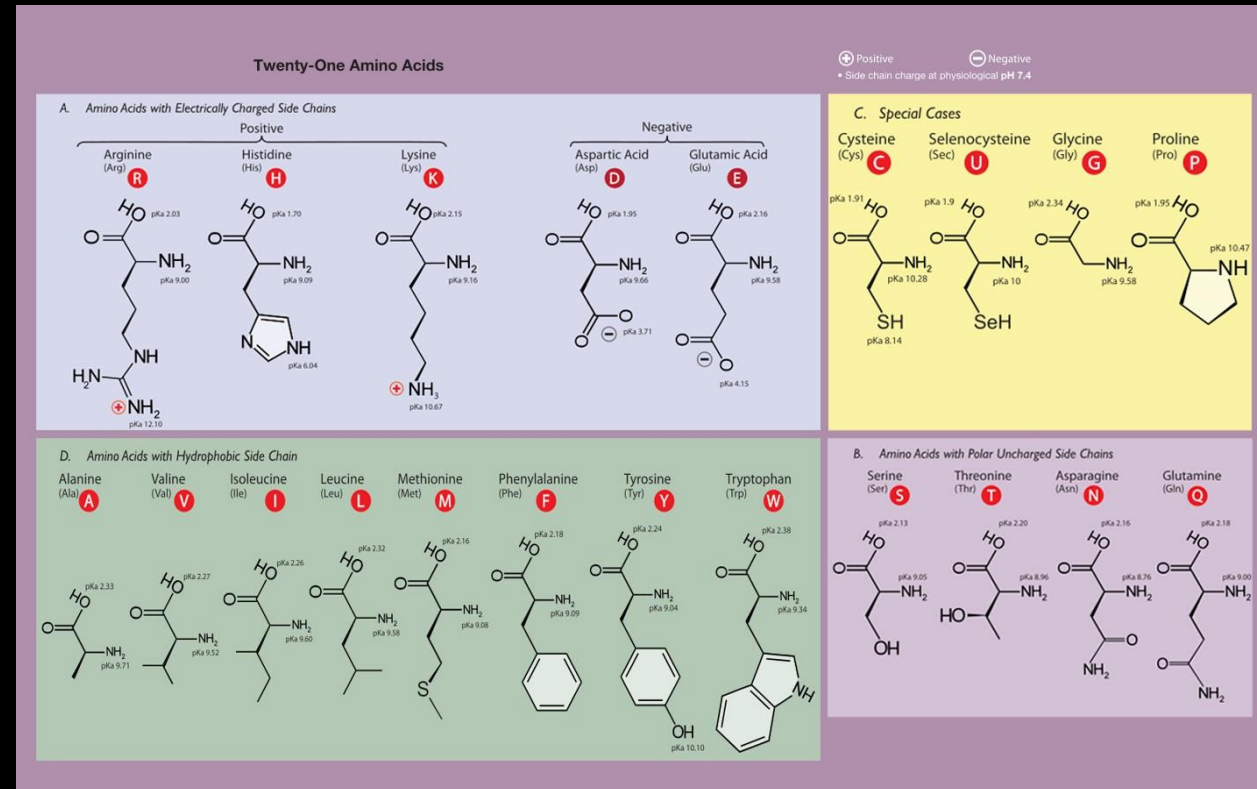
Macronutrients – [3] Proteins

- **proteins:** large macromolecules that comprise one or more long chains of amino acid residues
- Functions include enzymatic (catalytic), structural, regulatory, contractile, immunological, transport, and more



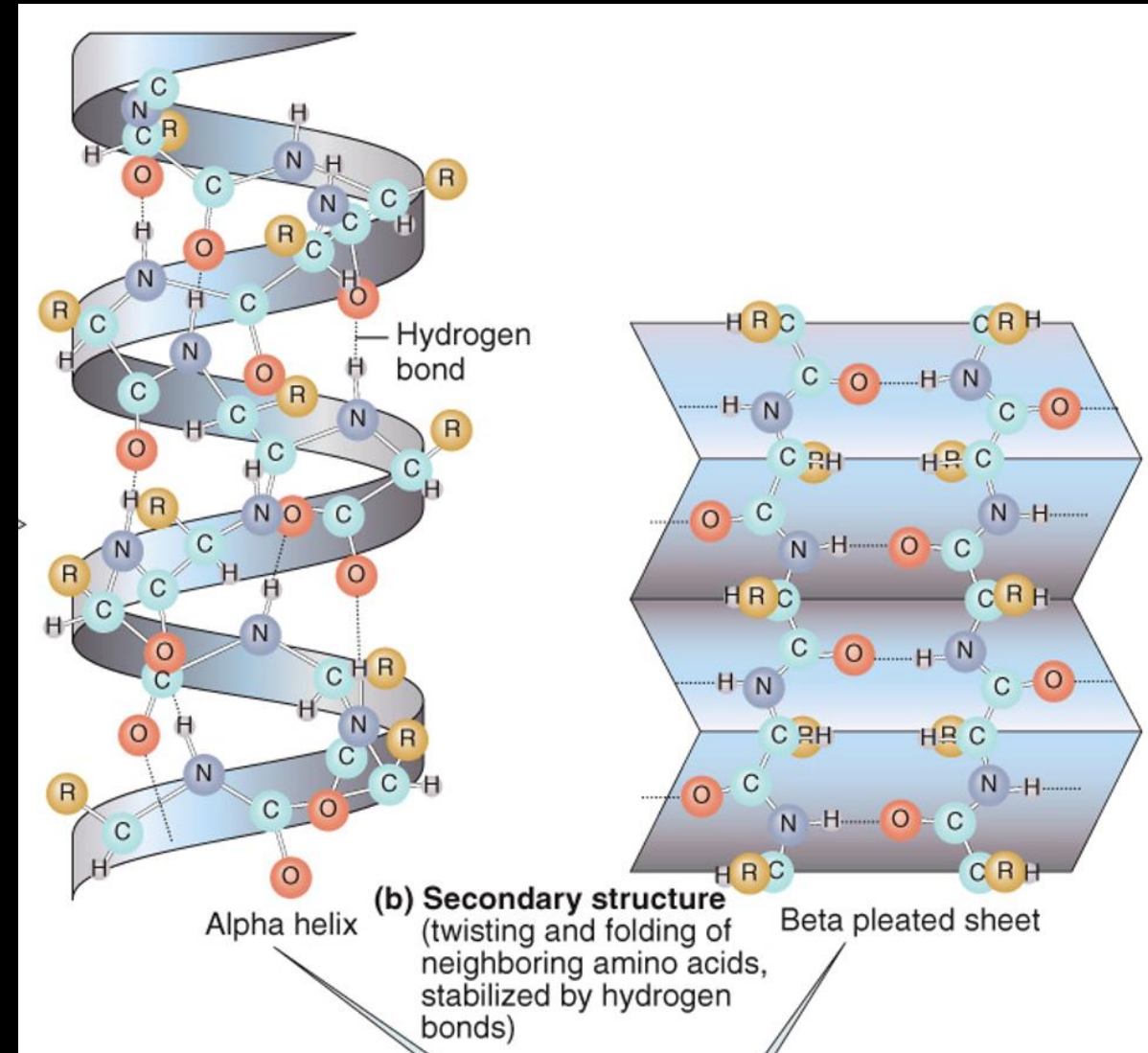
Amino Acids

- amino acids = the monomers (small organic molecules) of proteins
→ in total there are 20 amino acids that are used to assemble proteins (ex. tryptophan)
- peptide bond = the covalent bond joining each pair of amino acids



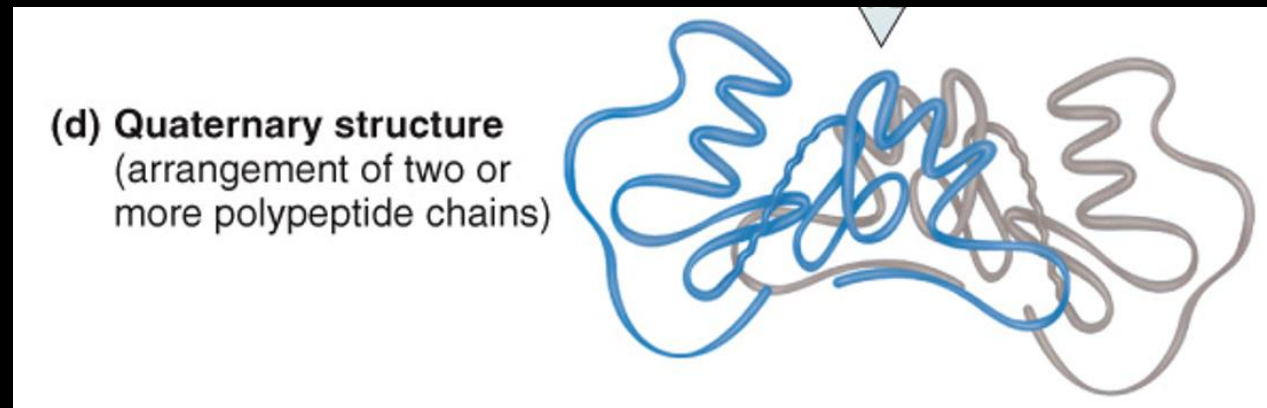
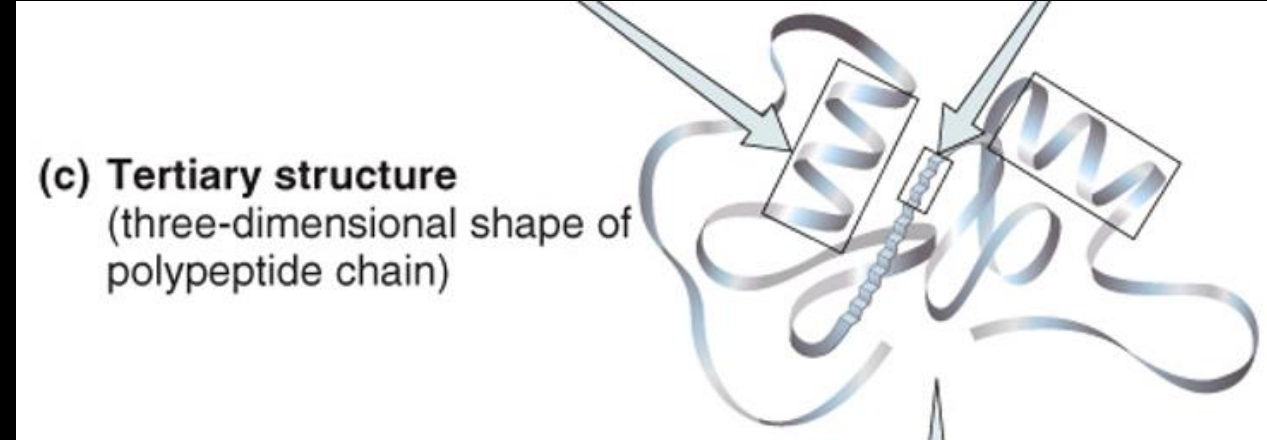
Protein Structure 1° & 2°

- Proteins exhibit 4 levels of structural organization:
- **primary structure:** the unique sequence of amino acids that are linked by covalent peptide bonds to form a polypeptide chain
- **secondary structure:** repeated twisting or folding of neighboring amino acids in the polypeptide chain two forms
 - alpha helixes
 - beta pleated sheets



Protein Structure 3° & 4°

- **tertiary structure:** 3D shape of a polypeptide chain
- **quaternary structure:** the arrangement of the individual polypeptide chains relative to one another in proteins that contain more than one polypeptide chain
 - Not all proteins have quaternary structure



Resources

- Dingess, Paige (2025)
- Grammarly. (2026). Grammarly (Version 14.1268.0) [Software].
<https://www.grammarly.com/>
- OpenAI. (2026). ChatGPT (GPT-5) [Large language model].
<https://chat.openai.com/>

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