

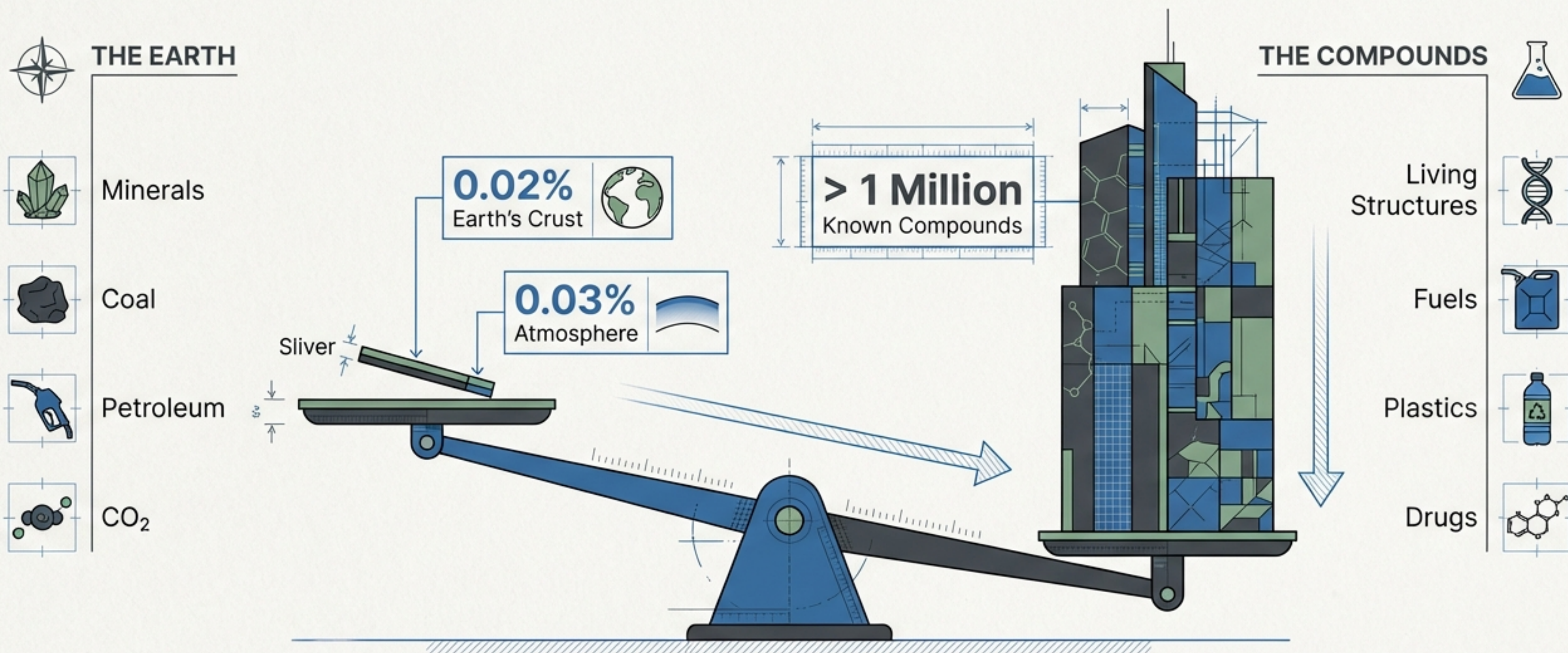
Carbon & Its Compounds: The Architect of Life

From atomic blueprints to the scaffolding of the living world.



Food, clothes, medicines, books—almost everything you use is based on this versatile element. Yet, Carbon is surprisingly rare.

The Carbon Paradox: Scarcity vs. Ubiquity



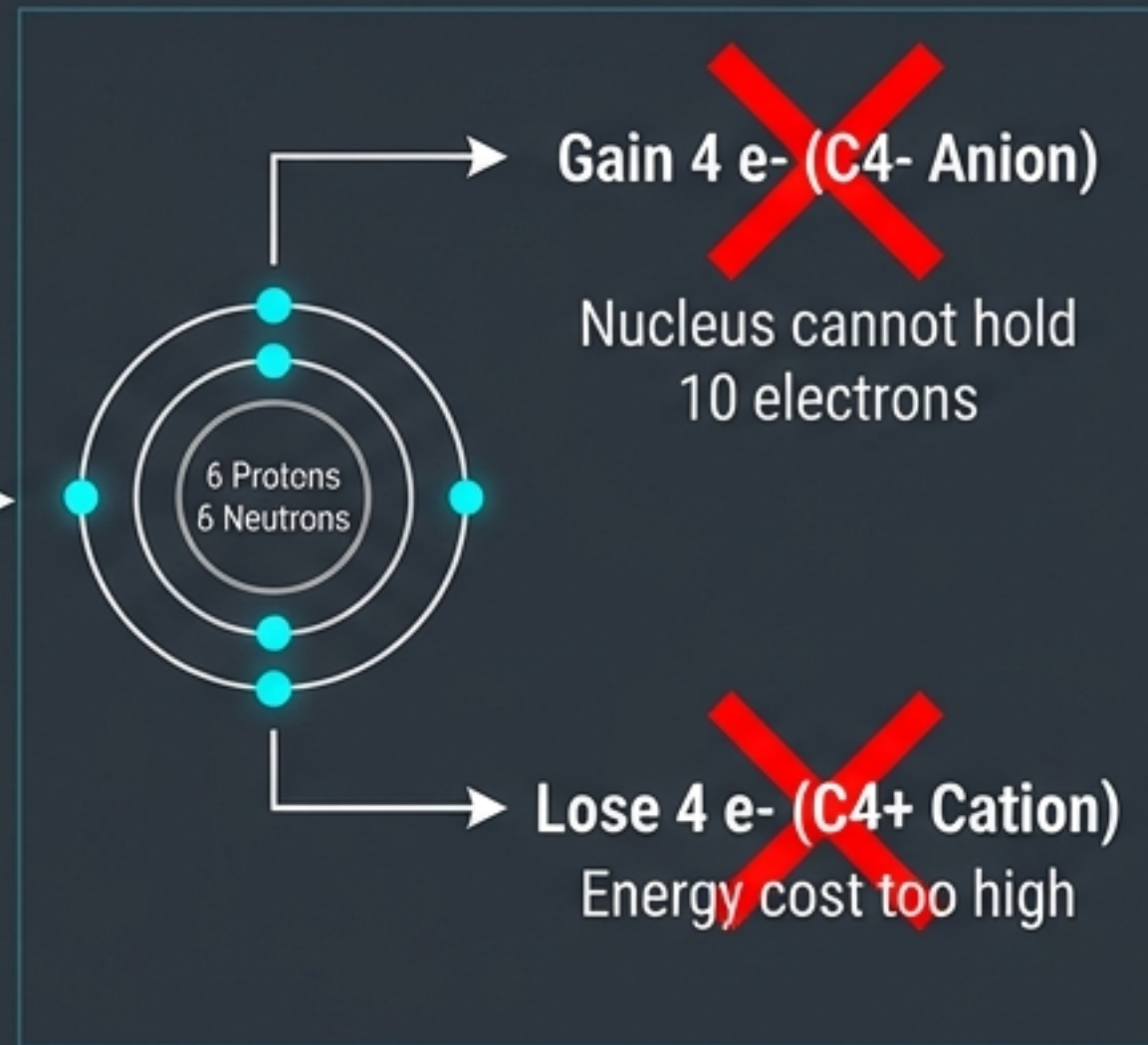
Despite meagre amounts in nature, Carbon is the essential ingredient for all living structures.
How does one element achieve so much with so little?

The Bonding Blueprint: The Problem of Four

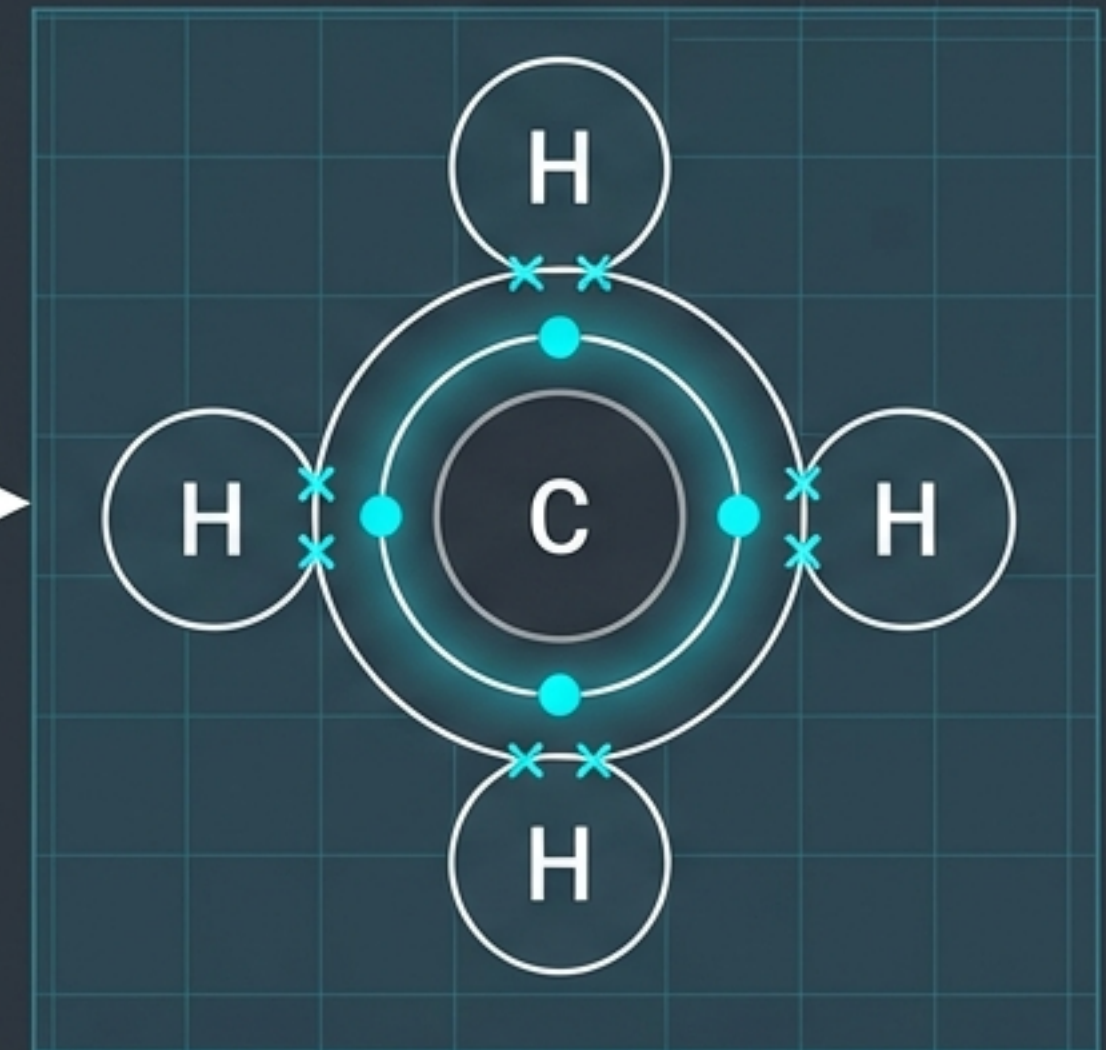
The Problem



The Dilemma



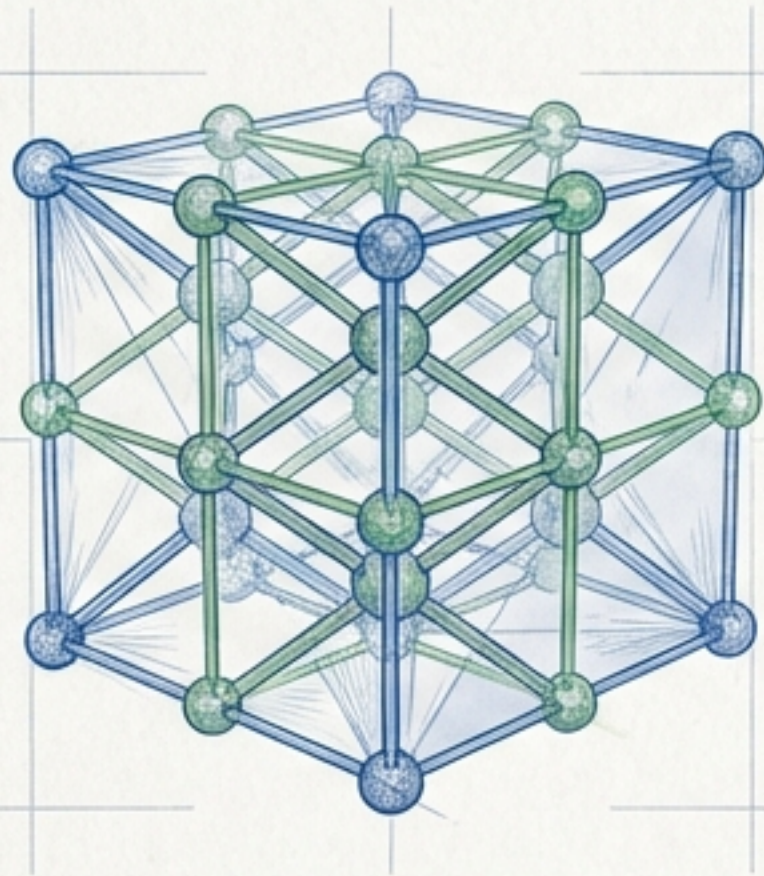
The Solution



Solution: Covalent Bonding.
Sharing electrons creates strong internal bonds but weak inter-molecular forces.

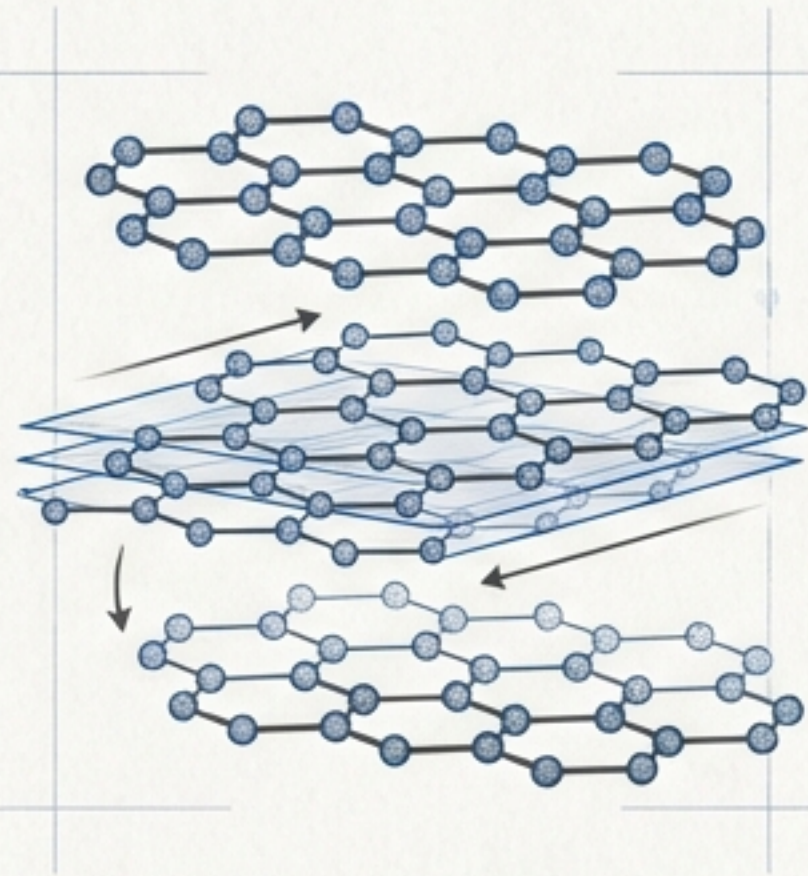
One Element, Many Faces: Allotropes

Diamond



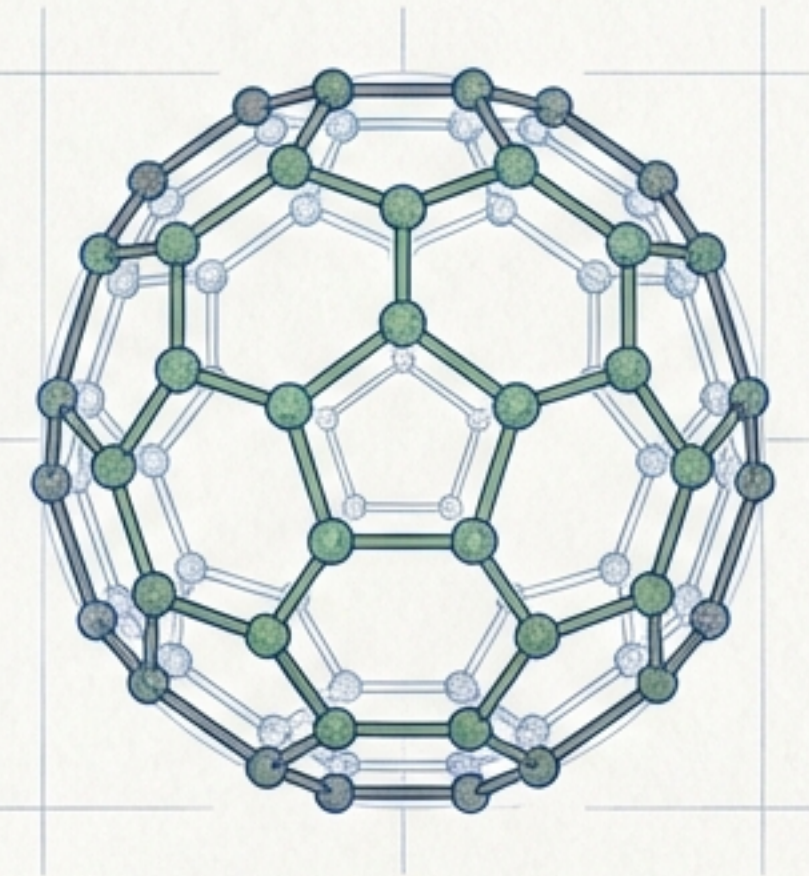
Rigid 3D Structure
Hardest Substance

Graphite



Layered Hexagonal
Slippery & Conductive

Fullerene (C-60)

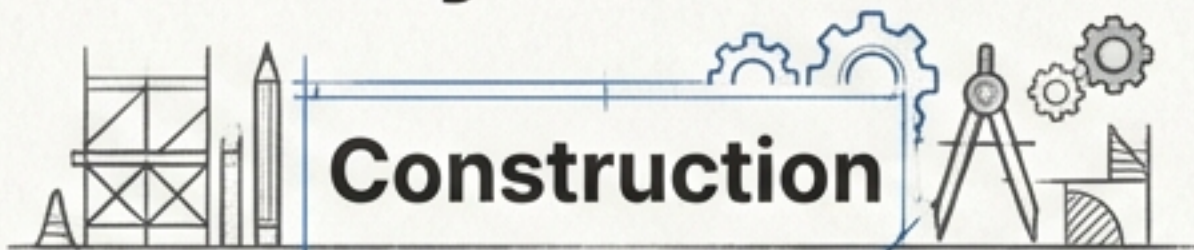


Geodesic Dome
Nanotechnology

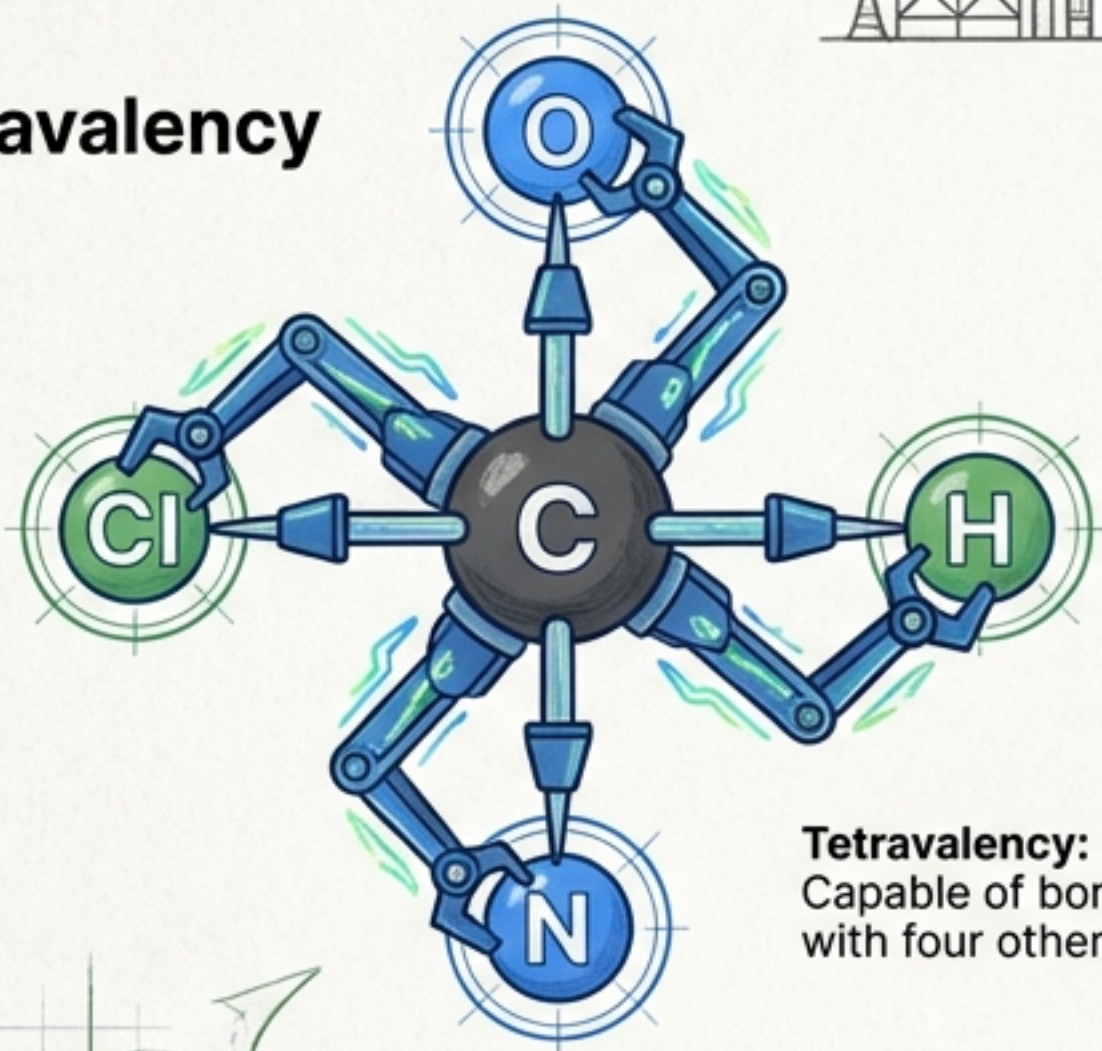


The manner of bonding changes everything. Identical chemical properties, opposing physical properties.

The Builder's Superpowers: Catenation & Tetravalency

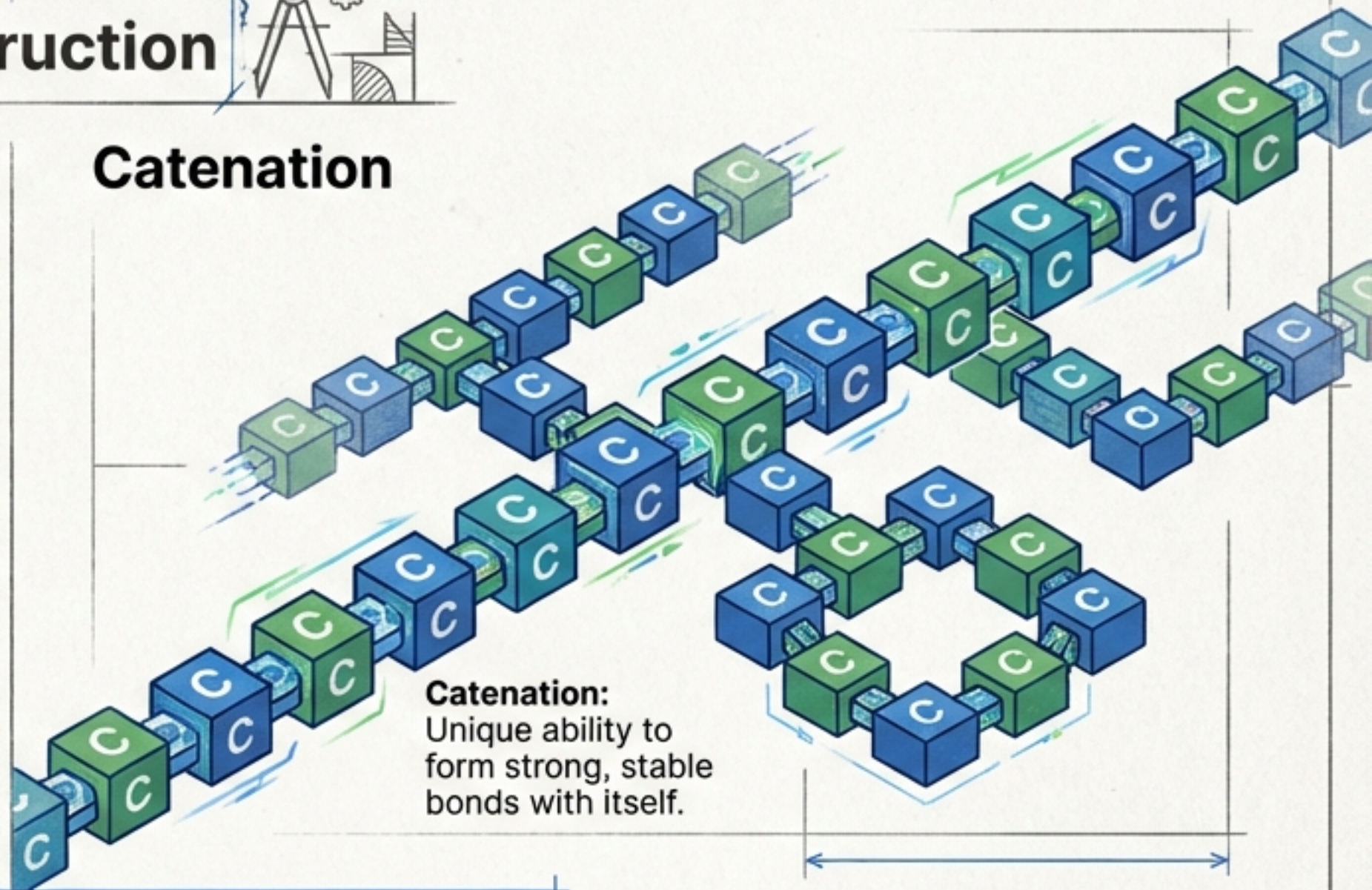


Tetravalency



Tetravalency:
Capable of bonding
with four other atoms.

Catenation



Catenation:
Unique ability to
form strong, stable
bonds with itself.

Comparison:

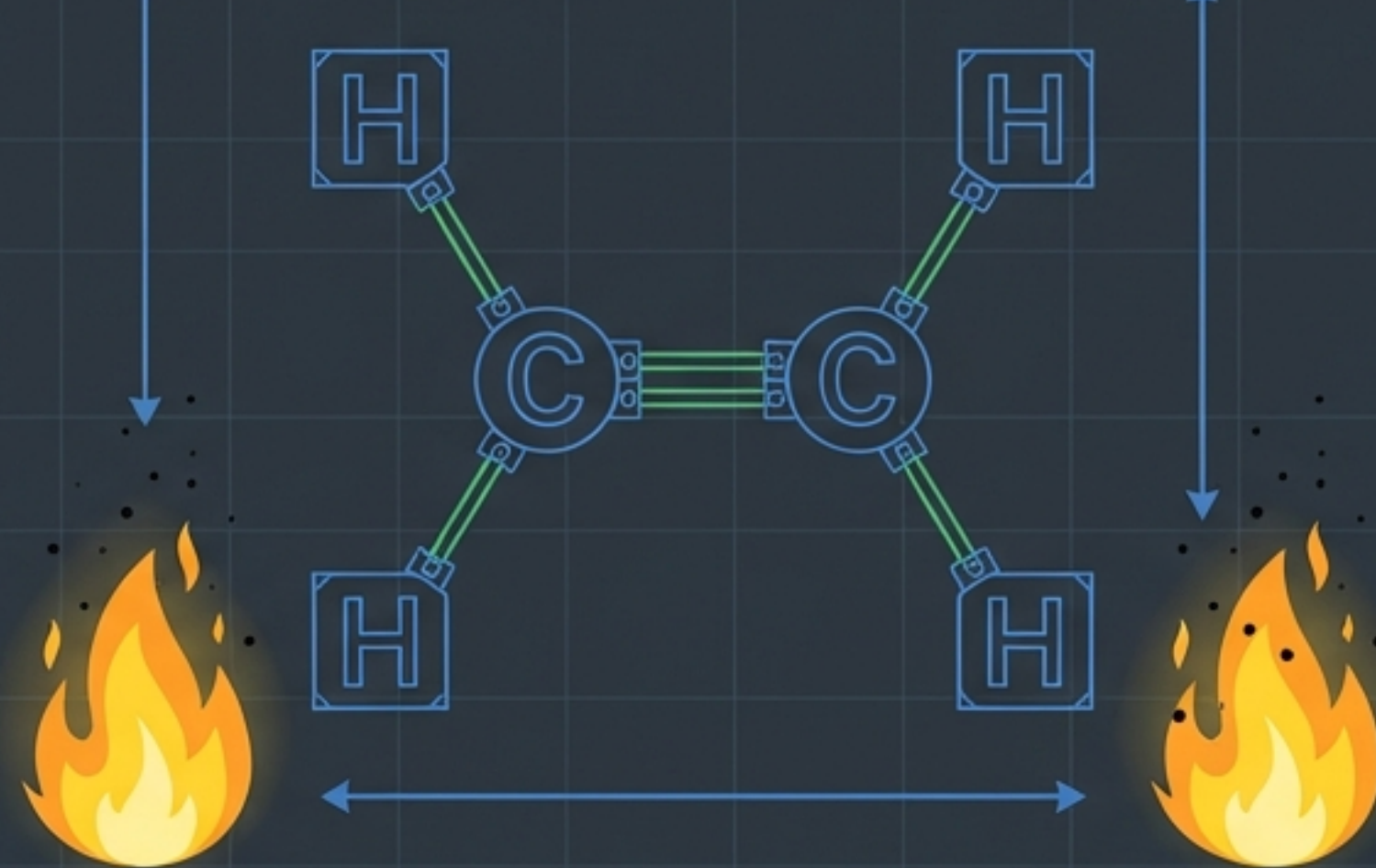
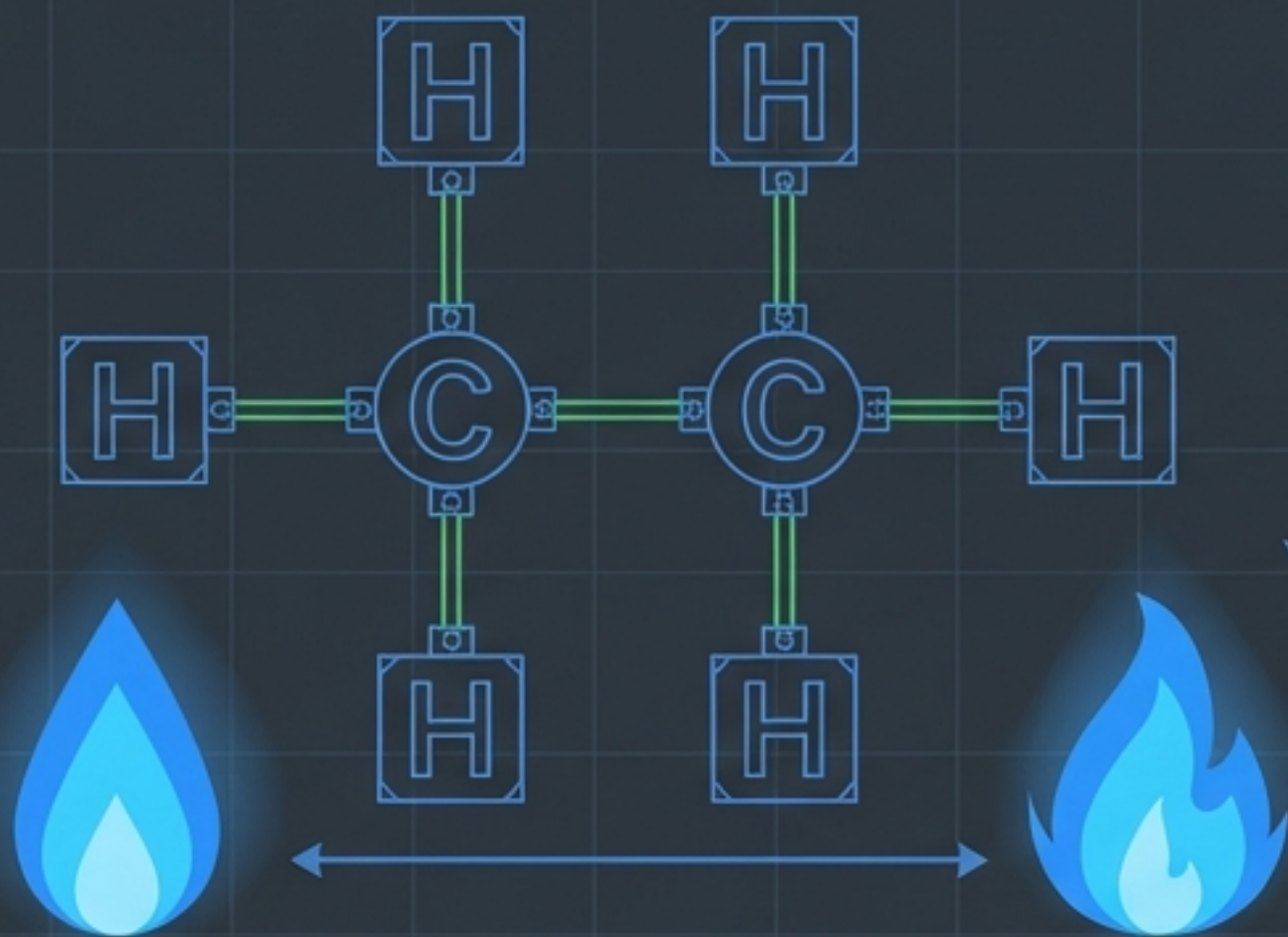
Silicon bonds are reactive and unstable.
Carbon bonds are strong and stable.



Connection Types: Saturated vs. Unsaturated

Saturated

Unsaturated



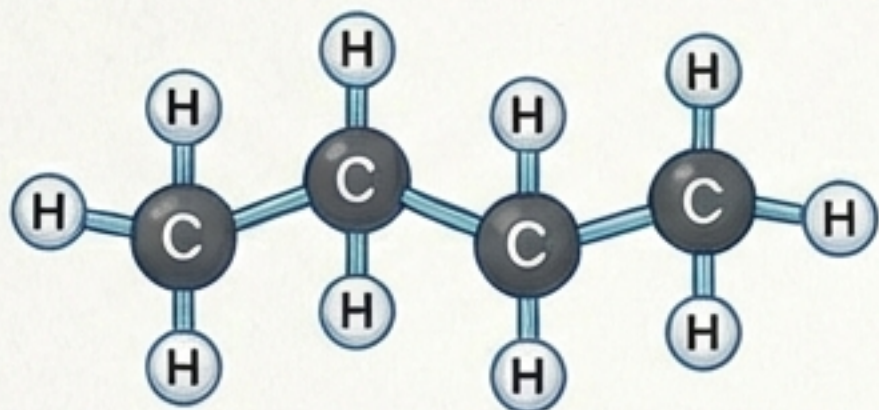
Alkanes (C-C Single Bond).
Unreactive. Clean Blue Flame.

Alkenes/Alkynes (Double/Triple Bond).
Reactive. Yellow Sooty Flame.

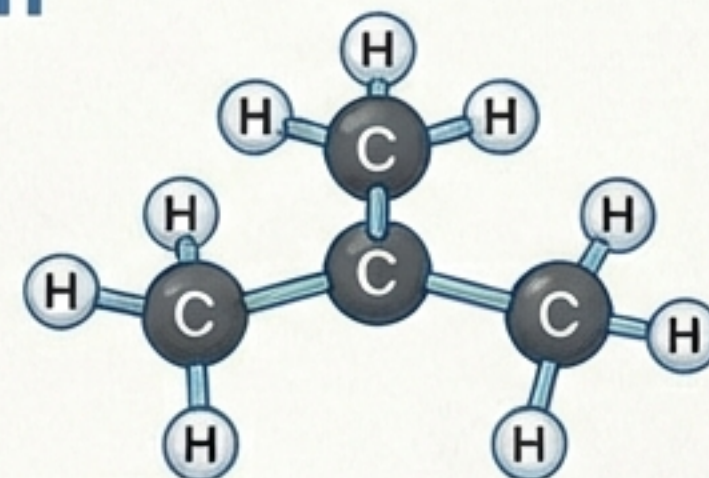
Alkanes: C_nH_{2n+2} | Alkenes: C_nH_{2n} | Alkynes: C_nH_{2n-2}

Architectural Shapes: Chains, Rings, and Isomers

Straight Chain vs. Branched Chain



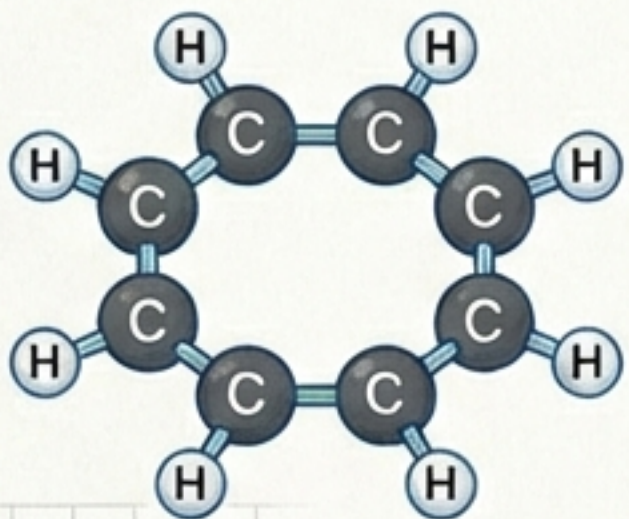
n-Butane



Iso-butane

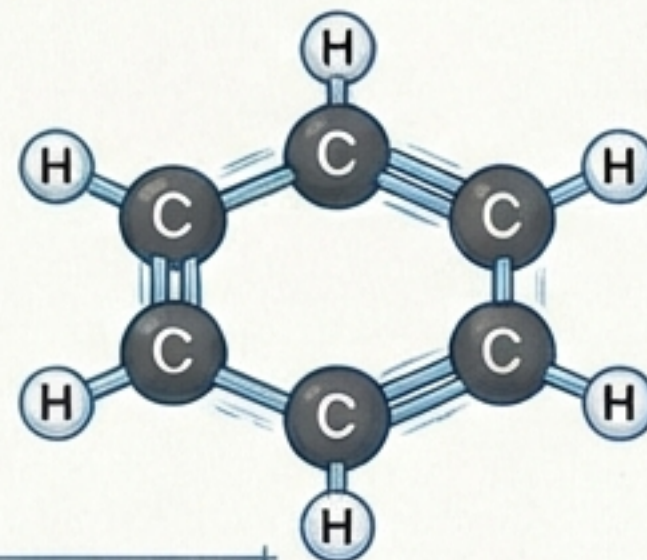
Isomers: Same Formula (C_4H_{10}), Different Structure.

Cyclic Saturated



Cyclohexane
 C_6H_{12}

Cyclic Unsaturated



Benzene
 C_6H_6

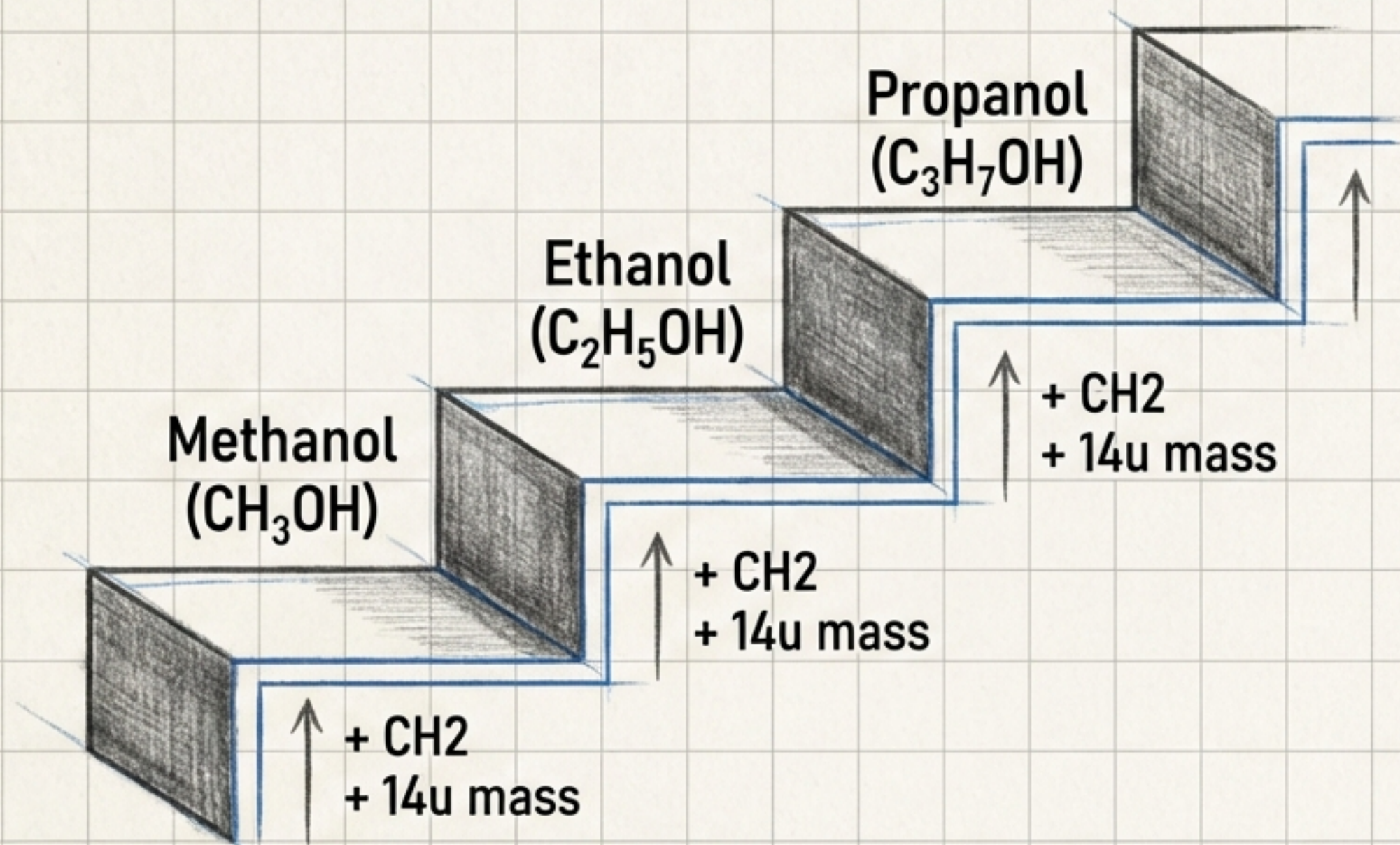
Hydrocarbons can assume many geometries.

Functional Groups: Adding Personality

Heteroatoms define the chemical behavior.

	Class of compounds	Formula of functional group	Prefix/Suffix
$\text{R} \begin{cases} \text{Cl} \\ \text{Br} \end{cases}$	Halogens	$-\text{Cl}, -\text{Br}$	Halo-
$\text{R}-\text{OH}$	Alcohol	$-\text{OH}$	Hydroxyl
$\text{R}-\overset{\text{O}}{\parallel}{\text{C}}-\text{H}$	Aldehyde	$-\text{CHO}$	Aldehyde
$\text{R}-\overset{\text{O}}{\parallel}{\text{C}}-\text{R}'$	Ketone	$-\text{CO}-$	Ketone
$\text{R}-\overset{\text{O}}{\parallel}{\text{C}}-\text{OH}$	Carboxylic Acid	$-\text{COOH}$	Carboxyl

The Homologous Series: A Chemical Family Tree



Pattern: Successive members differ by $-\text{CH}_2-$ unit.

Trend: Melting/Boiling points rise with mass.

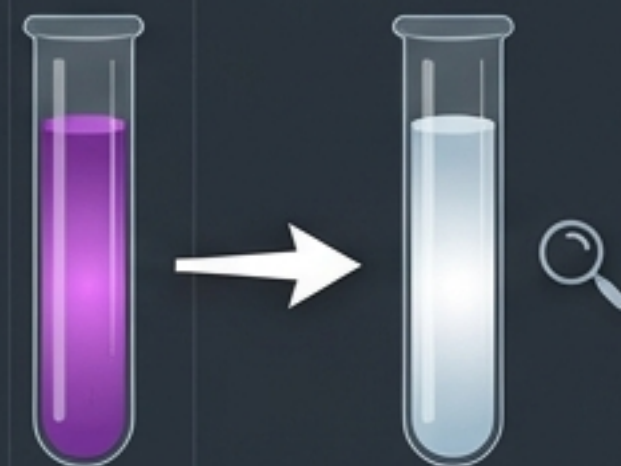
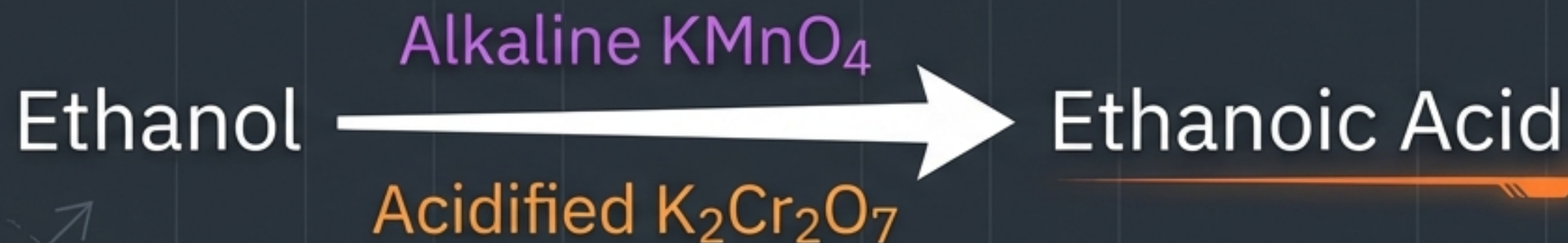
Consistency: Chemical properties remain similar.

Reactivity I: Releasing Energy & Adding Oxygen

Combustion



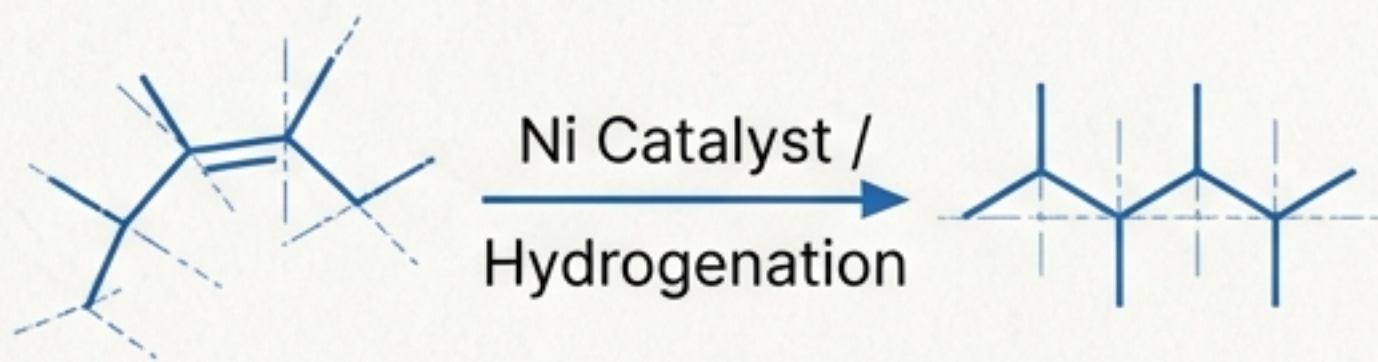
Oxidation



Oxidation is controlled combustion.

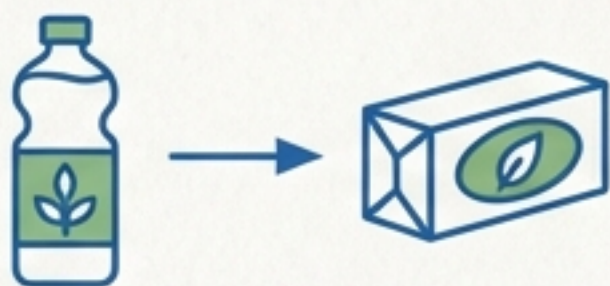
Reactivity II: Addition & Substitution

Addition

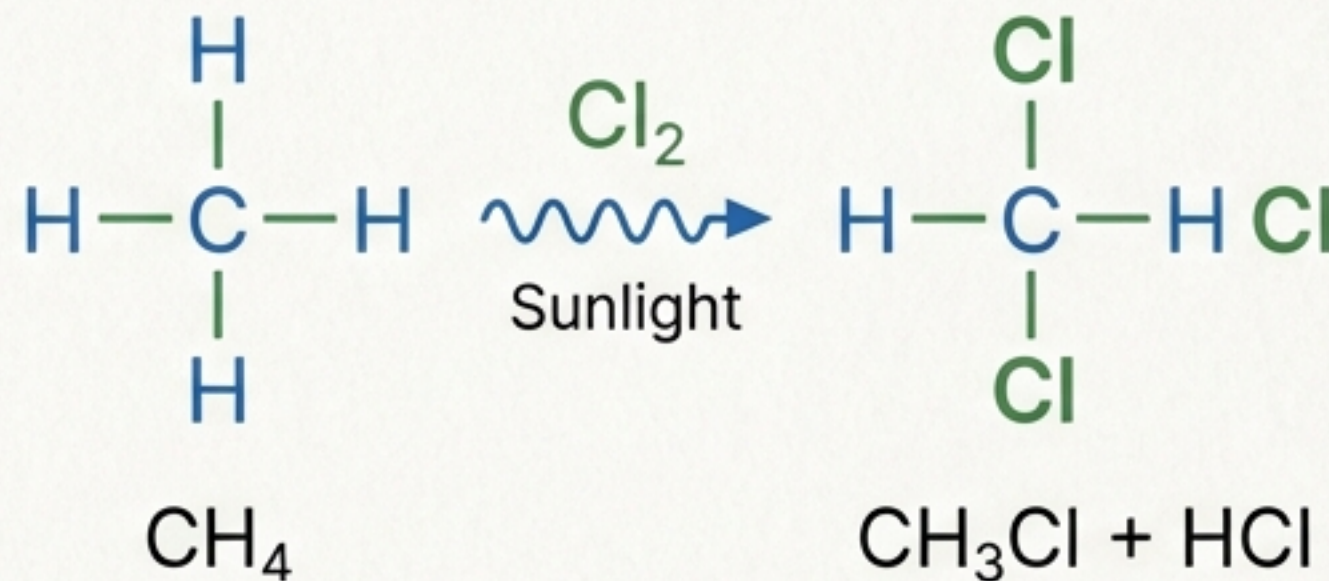


Unsaturated
Vegetable Oil

Saturated Fat



Substitution



Addition modifies the structure; Substitution swaps the parts.

Material Focus: Ethanol ($\text{CH}_3\text{CH}_2\text{OH}$)

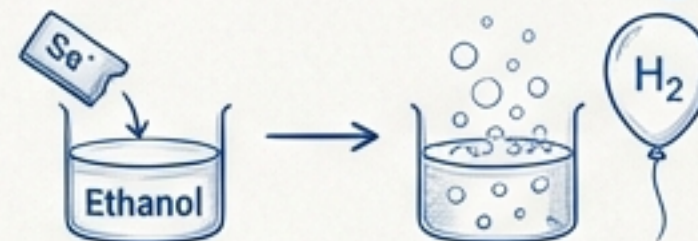
Uses

- Solvent (Tincture Iodine)
- Medicines
- Fuel

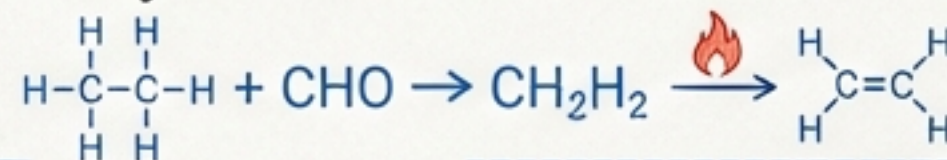


Reactions

Reacts with Sodium \rightarrow H_2 Gas



Dehydration \rightarrow Ethene



Danger

Methanol Poisoning:
Causes blindness/death



Industry

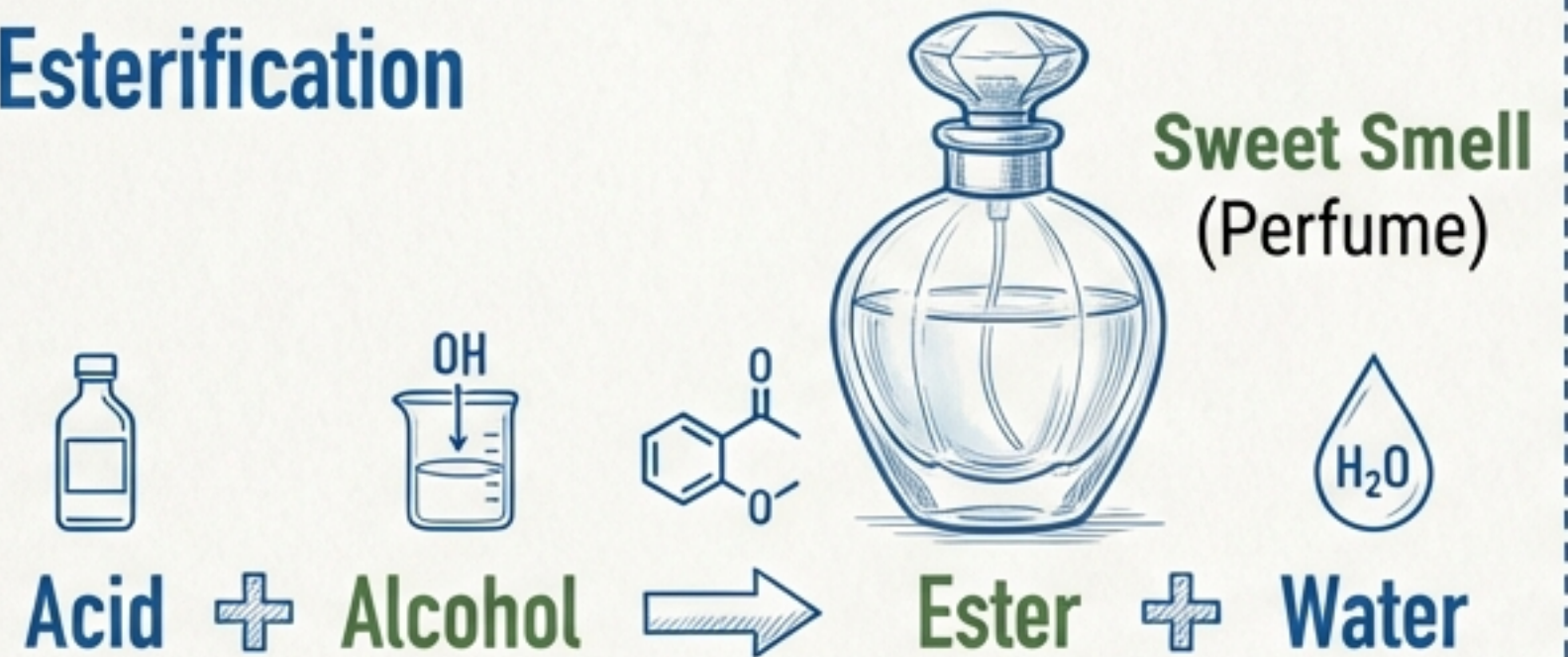
Denatured Alcohol:
Blue dye + Methanol
added to prevent
misuse



Material Focus: Ethanoic Acid (CH_3COOH)

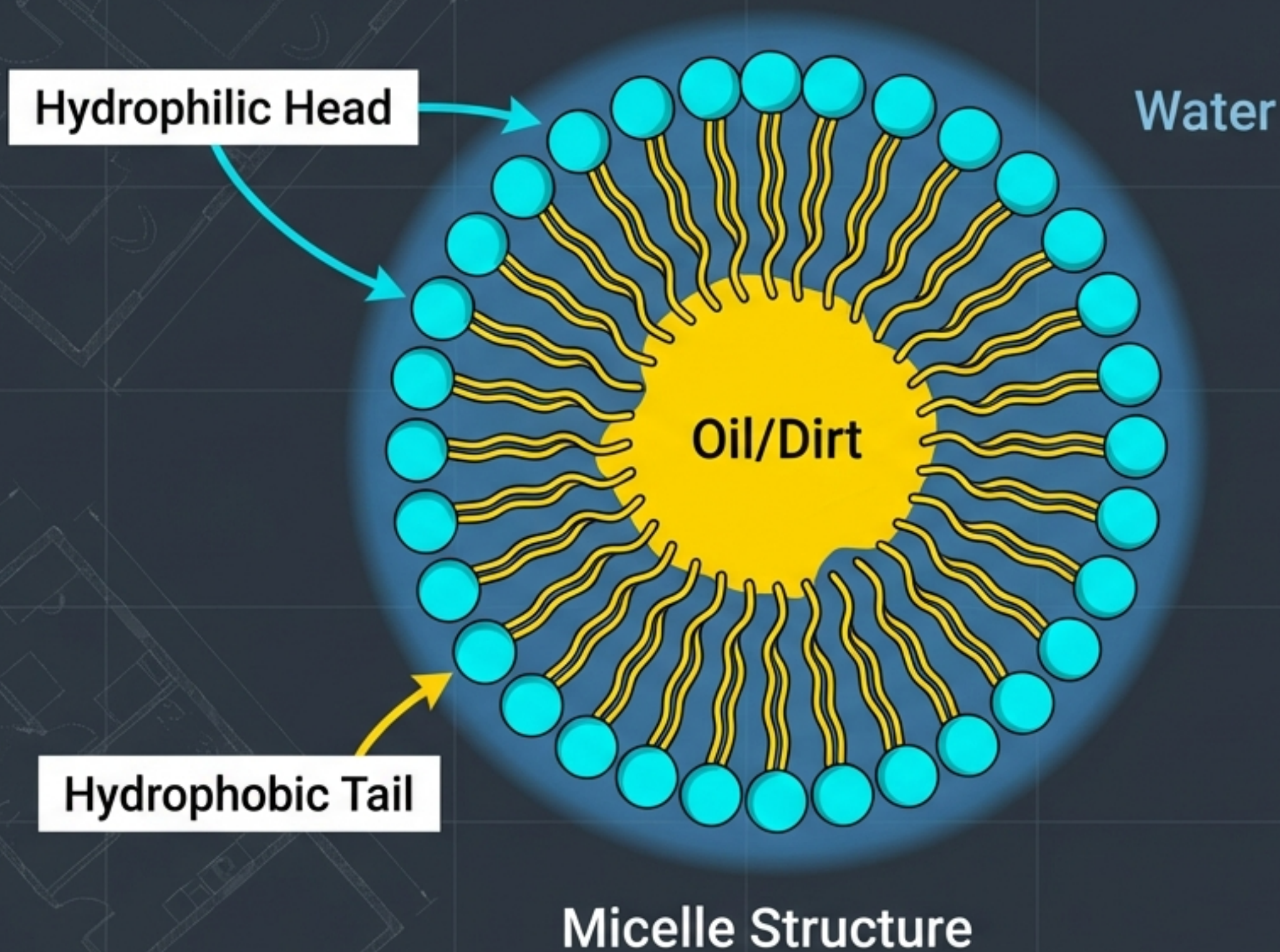


Esterification



Also reacts with **Carbonates** to release **CO_2** (Effervescence)

The Science of Cleaning: Soaps & Detergents



Soap

Sodium salts of fatty acids.
Forms scum in hard water
(Ca/Mg ions).

Detergents

Sulphonate salts.
Effective in hard water
(No scum).

Blueprint Complete: Summary

- ✓ 1. **Versatility:** Catenation and Tetravalency allow infinite structures.
- ✓ 2. **Bonding:** Covalent bonds (Sharing) create strong molecules.
- ✓ 3. **Diversity:** Chains, Branches, Rings, and Isomers.
- ✓ 4. **Function:** Heteroatoms determine reactivity (Functional Groups).
- ✓ 5. **Application:** From metabolic fuels to industrial detergents.

Carbon is not just an element; it is a system of infinite possibility.