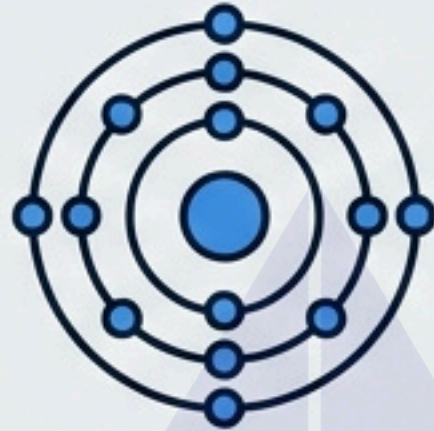


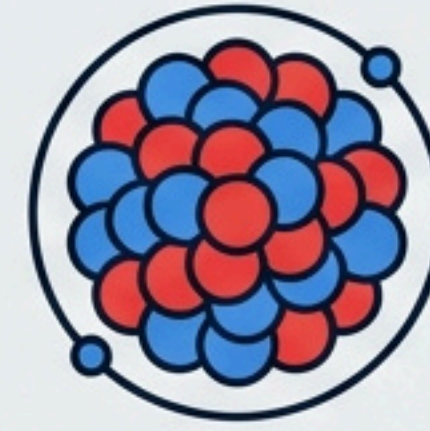
Why Nuclear Energy Is So Powerful



Rearranging Electrons

[eV Scale]

Exothermic chemical reactions (like burning coal or petroleum) involve energies in the range of a few electron volts. They only alter the outer structure of atoms.



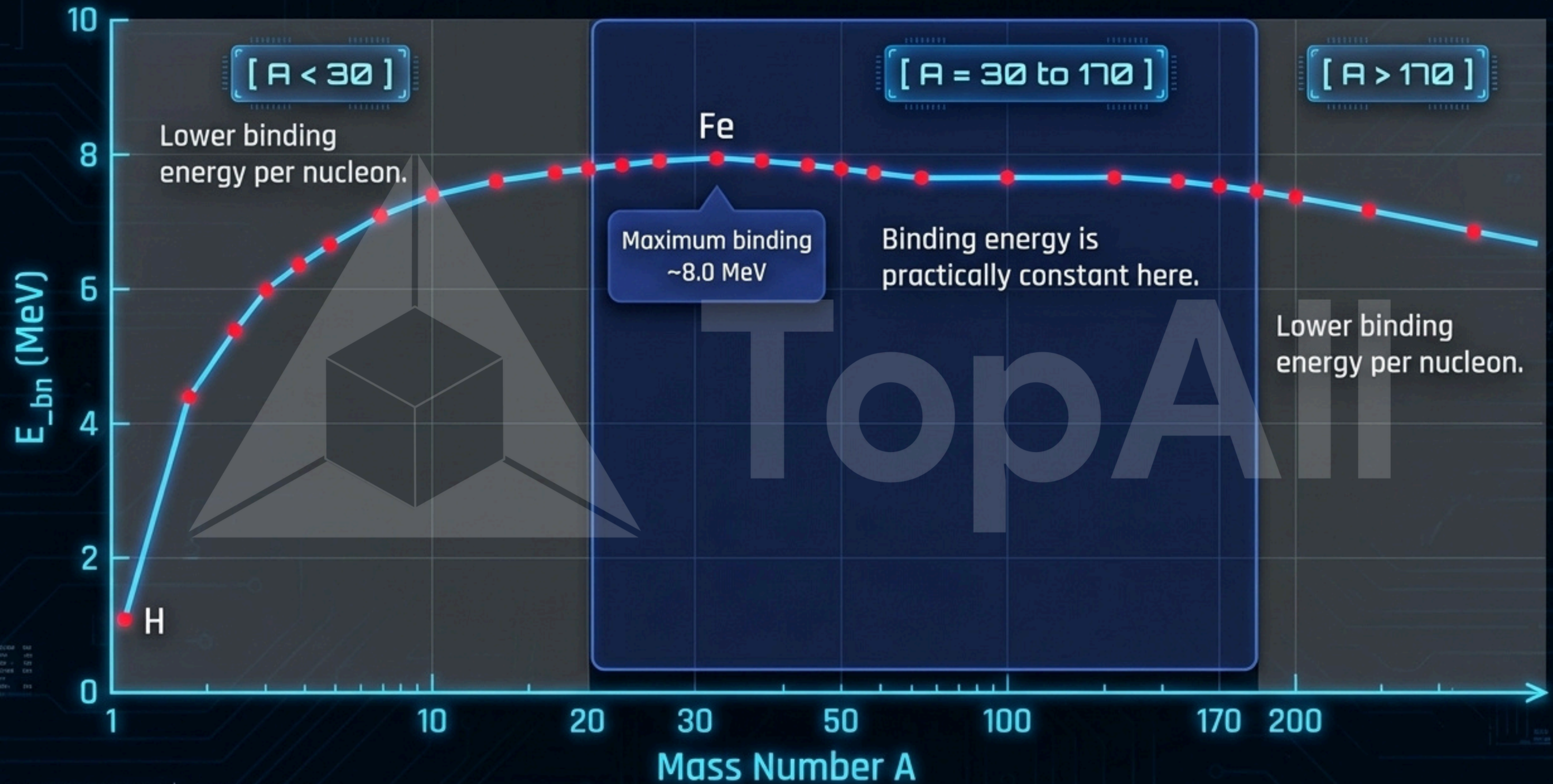
Rearranging the Core

[MeV Scale]

Nuclear reactions alter the tightly bound atomic nucleus itself. The energy released is of the order of millions of electron volts per reaction.

For the same quantity of matter, nuclear sources produce around a million times more energy than a chemical source.

The Binding Energy Per Nucleon Curve



Greater Binding Means Lower Mass

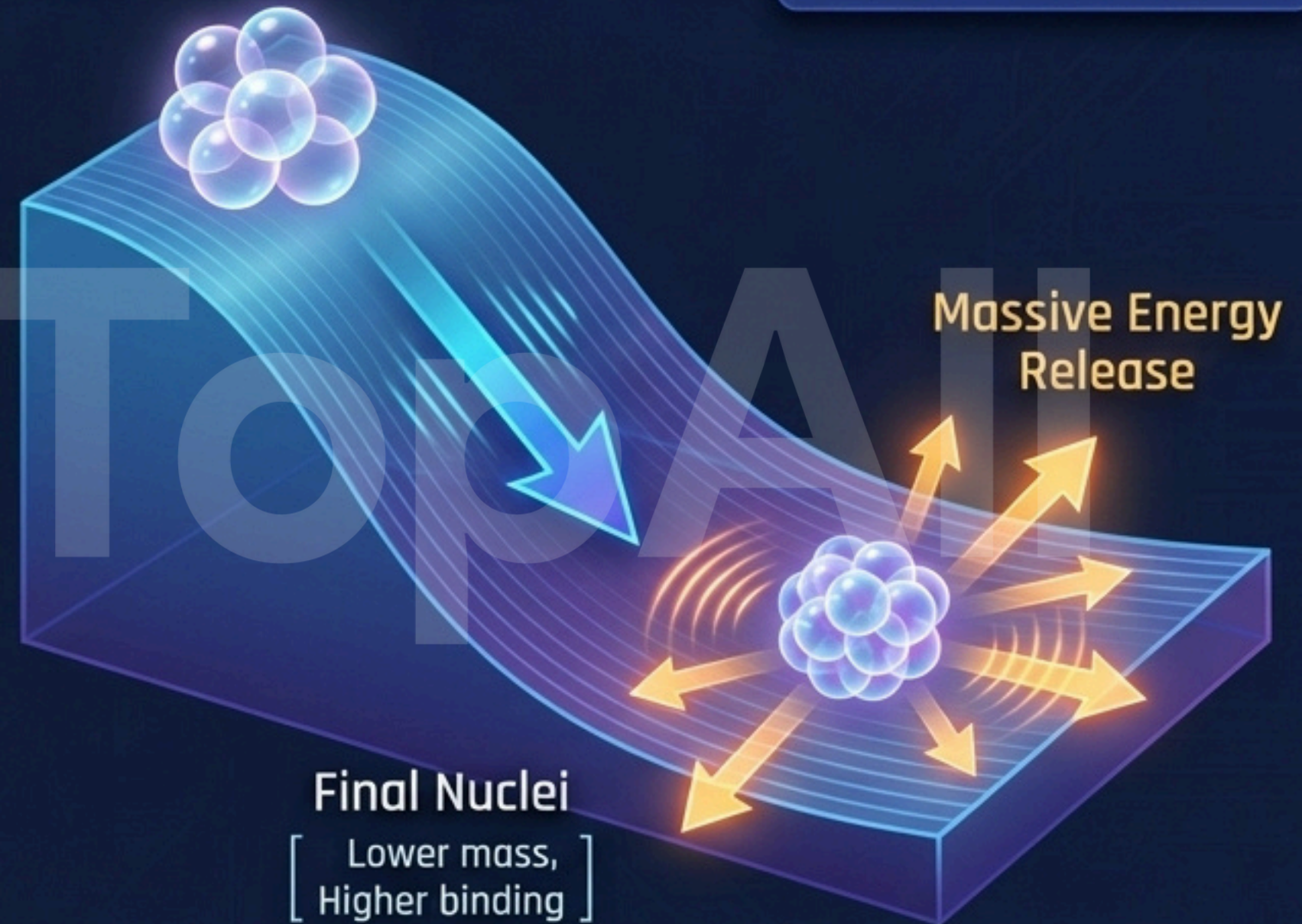
The Mass-Energy Exchange

The greater the binding energy, the less the total mass of the bound system.

If nuclei with less total binding energy transform into nuclei with greater binding energy, the missing mass is converted into a massive net energy release.

Initial Nuclei
[Higher mass, Lower binding]

$$\Delta E = \Delta mc^2$$





**You've Learned the Theory.
Let's Test Them Now.**

$$E=mc^2$$



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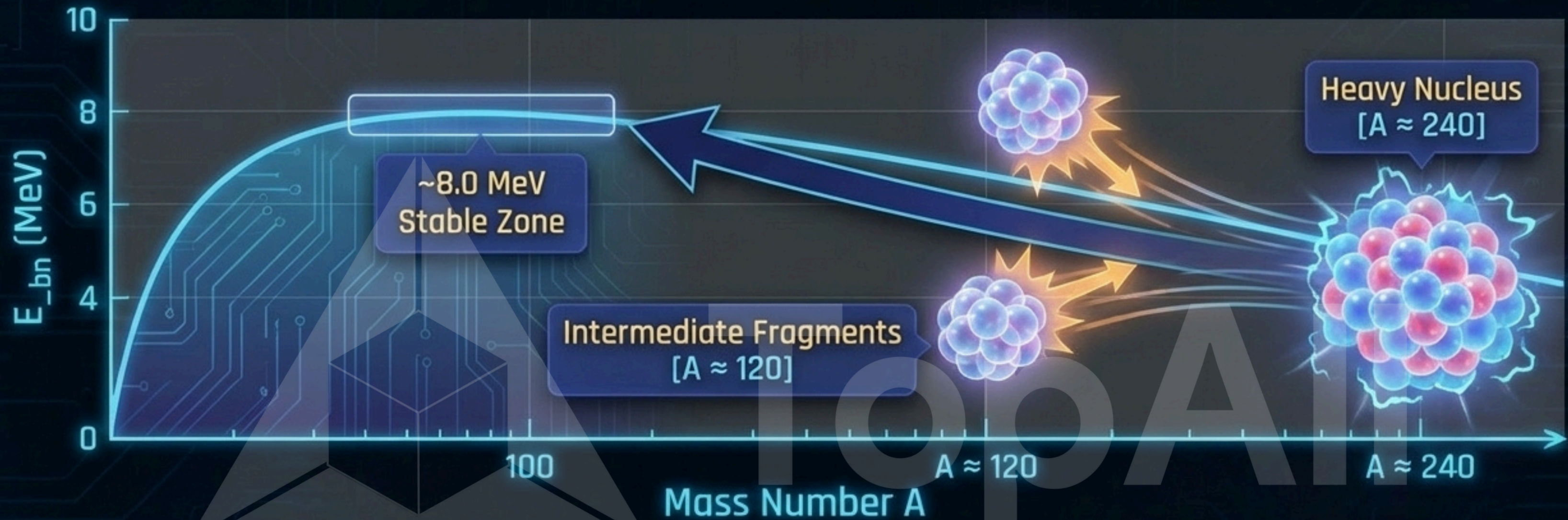
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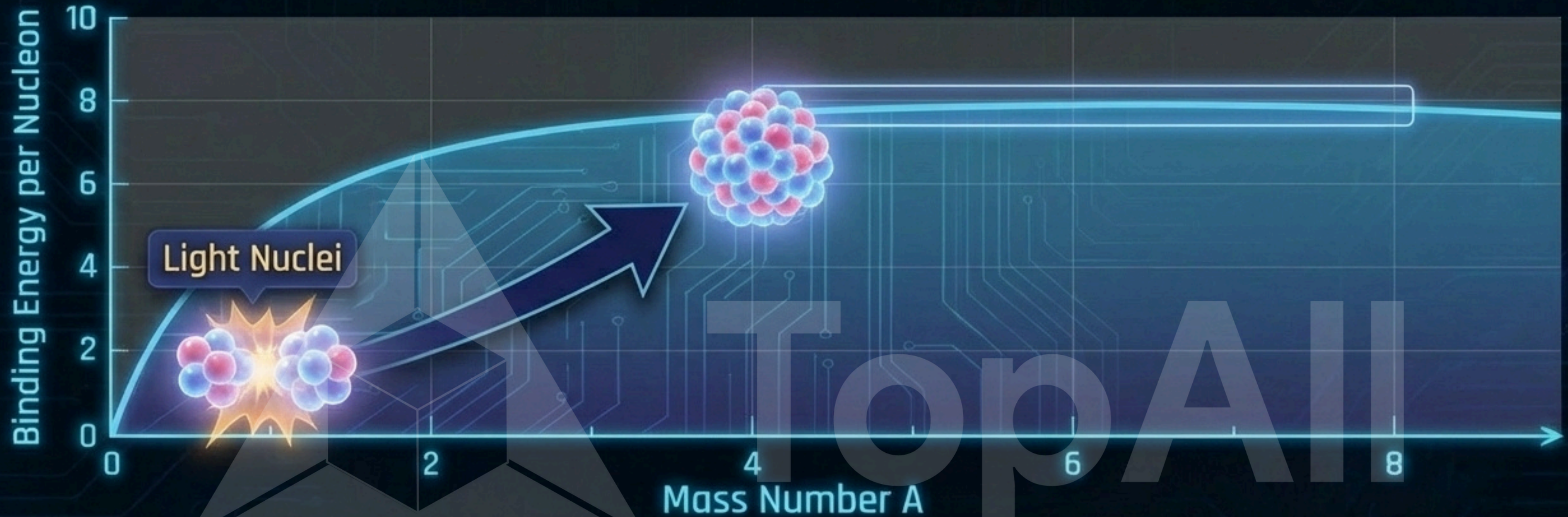
The Fission Path: Splitting to Stabilize



Breaking Heavy Nuclei

Heavy nuclei ($A > 170$) are **less tightly bound**. When a heavy nucleus decays into **intermediate mass fragments**, the new nucleons land in the flat middle region. Because they are now more tightly bound, the difference in mass is **released as heat and kinetic energy**.

The Fusion Path: Joining to Stabilize



Joining Light Nuclei

Light nuclei ($A < 30$) have **very low binding energy**. If they overcome the coulomb barrier and fuse into a heavier nucleus, the final system becomes significantly more tightly bound. This massive energy release is the primary energy source of the sun and stars.

Energy Yield: Uranium vs. Coal



EXOTHERMIC CHEMICAL REACTION

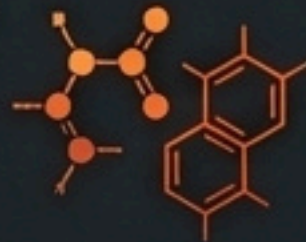
Burning 1 kg of Coal

10^7 Joules

Energy Release



Chemical bonds are broken and reformed. The energy release is limited by the **electron volt (eV)** scale.



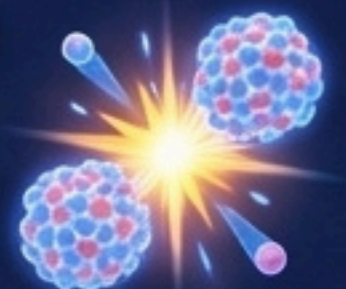
EXOTHERMIC NUCLEAR REACTION

Fission of 1 kg of Uranium

10^{14} Joules

Energy Release

Atomic nuclei are split, moving toward a state of greater binding energy. The **mass defect is converted directly into energy** via $E=mc^2$.



For the exact same mass, the nuclear reaction yields **10,000,000x** more energy.

Key Takeaways: Nuclear Energy

[$A = 30$ to 170]

The binding energy curve features a flat middle region where E_{bn} is practically constant at ~ 8.0 MeV.

[Lower Stability]

Both lighter ($A < 30$) and heavier ($A > 170$) nuclei have significantly lower binding energy values.

[The Energy Rule]

Energy is released whenever less tightly bound nuclei transform into a state of greater binding energy (lower total mass).

[The Two Routes]

Fission achieves this by splitting heavy nuclei; Fusion achieves this by joining light nuclei.

[The Magnitude]

Nuclear energy yields roughly a million times more energy than chemical reactions (10^{14} J for 1kg Uranium vs 10^7 J for 1kg Coal).



You've Learned the Theory.

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