# How does nuclear fusion work?

KS3 KS4 Ages 11-16 ⏰ 5 min read

The Sun produces more energy in one second than humanity has used in its entire history. It does this not by burning fuel, not through chemical reactions, but by fusing atoms together. For decades, scientists have been trying to replicate that process here on Earth — with the promise of virtually unlimited, clean energy. Here's how fusion actually works.

## Fission vs fusion — what's the difference?

Today's nuclear power plants use **fission** — splitting large, heavy atoms (usually uranium) apart to release energy. Fusion is the opposite: taking very small, light atoms and pushing them together. Both release enormous amounts of energy, but fusion has huge advantages. The fuel (hydrogen isotopes) is effectively inexhaustible, the reaction produces no carbon emissions, and unlike fission, it produces no long-lived radioactive waste.

🧲 Imagine two strong magnets, both with the same pole facing each other. Normally they push apart. But if you could shove them together hard enough, they'd snap into a new combined shape and release a burst of energy in the process. Atomic nuclei are like those magnets — they're positively charged and naturally repel each other. Fusion is the process of forcing them together so hard they merge, releasing a tremendous amount of energy.

## Why is it so hard?

To overcome the repulsion between nuclei, you need to heat them to extraordinary temperatures — over 100 million degrees Celsius, which is actually hotter than the core of the Sun (the Sun uses gravity to compensate). At those temperatures, matter becomes a plasma — a superheated soup of nuclei and electrons. The challenge is containing that plasma, because no physical material can withstand those temperatures. Current fusion reactors use powerful magnetic fields to hold the plasma in a doughnut-shaped loop, never touching the walls.

## Has it worked?

In December 2022, the National Ignition Facility in the US achieved a historic milestone: they put less energy in than they got out of a fusion reaction. It was the first time this had ever been done. The energy gain was modest, and the broader infrastructure needed far more energy — but it proved the principle. The ITER project in France — an international collaboration building the world's largest fusion reactor — is due to begin plasma experiments in the late 2020s. Most physicists believe commercial fusion power is now a matter of when, not if, though estimates of "when" vary from 20 years to the end of the century.


Free for educational use