How do magnets work?

KS3 Ages 11-14 ⏰ 3 min read

Magnetism comes from electrons. Specifically, from the fact that electrons spin (well, not literally — it's a quantum property, but "spin" is the name physicists gave it), and spinning electric charges create magnetic fields.

In most materials, electrons spin in random directions, and all the tiny magnetic fields cancel each other out. But in magnetic materials like iron, electrons in some atoms align their spins in the same direction. When billions of atoms all have their electrons spinning the same way, their magnetic fields add up into something large enough to pick up a paperclip.

Imagine a crowd of people all waving their arms randomly in different directions — the overall effect is chaos. Now imagine a Mexican wave: everyone waves in the same direction at the same time. That coordinated movement creates something visible from across a stadium. Magnetism is a Mexican wave of electron spins. Uncoordinated: no magnet. Coordinated: magnet.

Why do opposite poles attract?

Every magnet has a north pole and a south pole — and the rule is that opposite poles attract, while like poles repel. This comes from the direction of the magnetic field. The field lines flow from north to south outside the magnet. When you bring two magnets together with opposite poles facing, the field lines from each magnet flow in the same direction between them — they reinforce each other and pull the magnets together. Like poles create opposing fields that push away.

Can you cut a magnet in half?

Yes, and you get two smaller magnets, each with their own north and south poles. Cut those in half again — still two poles each. The poles come in pairs because they're not separate sources; they're the two ends of the same magnetic field. As far as we know, a magnetic monopole (a north pole with no corresponding south) doesn't exist, though physicists have been looking for one for decades.

What's the connection between electricity and magnetism?

They're the same force, from different angles. Moving electric charges create magnetic fields — this is how electromagnets work. Changing magnetic fields create electric currents — this is how generators work. James Clerk Maxwell unified electricity and magnetism into one theory in the 1860s: electromagnetism. It was one of the greatest achievements in physics, and it ultimately led Einstein towards his theory of relativity.