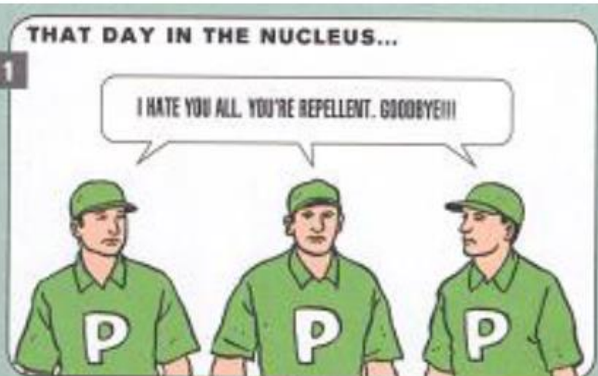
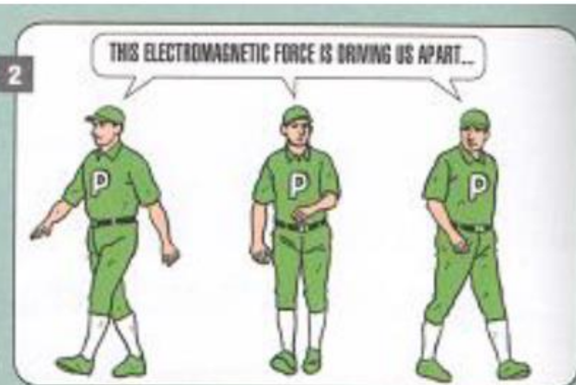
What Holds Atoms Together?

Electrons, being negatively charged, are held in atoms by electrostatic attraction toward the nucleus, which is positively charged because of the presence of protons. The nucleus itself is held together by the mighty nuclear force.

How is it that protons, which should not hang out together at close quarters, do so in the nucleus of every atom?

Inside an atomic nucleus, an intense conflict plays out between two powerful forces. These are the electromagnetic force—which causes like charges (such as protons) to repel and unlike charges to attract—and the nuclear force, which pulls protons and neutrons together. Normally, the nuclear force wins out...



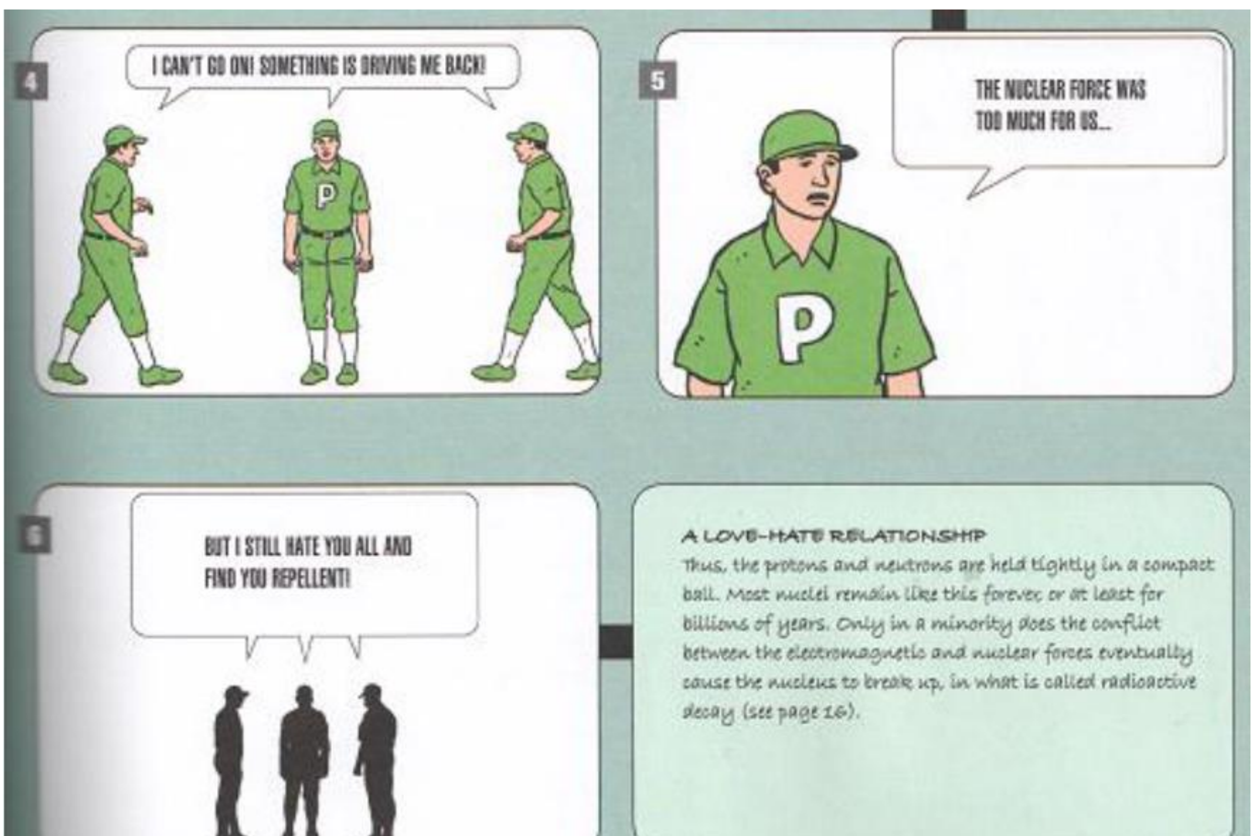


EFFECTS OF THE ELECTROMAGNETIC FORCE

Because the electromagnetic force causes like electrical charges (positive-positive or negative-negative) to repel, the positively charged protons in the nucleus are constantly pushing away from each other.

EFFECTS OF THE NUCLEAR FORCE

Fortunately, the even more powerful nuclear force overrides the electromagnetic force and pulls all the protons and neutrons together. If this didn't happen, the world as we know couldn't exist, because any atoms that formed would immediately break up. The nuclear force is closely linked to (some physicists consider it a "leakage" of) yet another force that operates inside protons and neutrons known as the "strong" force (see Composite Particles, page 23).

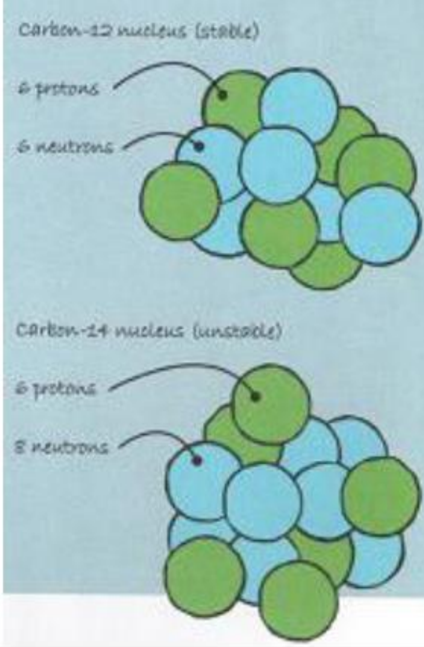


Radioactivity

Not all atoms are stable. While most are likely to last for hundreds of billions of years, some contain a particular combination of protons and neutrons in their nuclei that makes them unstable—this is because of conflicts between the forces operating inside the nuclei (see page 14). As a result, the nuclei of these atoms eventually disintegrate, or at least change in some way—in a process called radioactive decay.

What are Isotopes?

Each chemical element can exist in a number of different forms called *isotopes*. These vary in having different numbers of neutrons in their atomic nuclei. Isotopes have names like oxygen-14 or lead-206—the number after the name of the element denotes the total number of protons and neutrons in the atomic nuclei of that isotope. Some isotopes are stable, others unstable. For example, carbon-12—by far the most common isotope of carbon—is stable, while carbon-14—a much less common isotope—is unstable and will eventually decay.



Types of Radioactive Decay

When radioactive isotopes decay, their nuclei usually emit one of two types of particles, called alpha and beta particles. They may also give off gamma rays. These three types of emission vary in how energetic, penetrating, and hazardous to health they can be.