Inside the atom

If you could take a look inside the atom, you would probably see nothing – atoms are mostly empty space.

Break down matter into smaller and smaller pieces, and eventually you come to the smallest possible particle of any substance. Atoms are so tiny that about six million of them could fit on the period at the end of this sentence.

Atoms were once thought to be the ultimate, unsplittable building blocks of the universe. The word “atom” comes from the Greek atoms, meaning indivisible, and until New Zealand physicist Ernest Rutherford smashed atoms of nitrogen in 1919 at the Cavendish Laboratory, Cambridge, England, it was thought impossible to split matter into anything smaller than a atom. Atoms were imagined to be like solid indestructible balls. In fact, scientists now think of them as being more like clouds of energy – mostly empty space dotted with even tinier subatomic particles.

The model of the atom accepted in the 1960s has a dense nucleus with electrons orbiting around it in various layers, called shells. In the nucleus of all atoms except hydrogen, there are both protons and neutrons.

The nucleus is actually minute compared with the space occupied by the atom. In 1931, Rutherford worked out, from what happened to a stream of particles fired at metal foil, that the nucleus was about 10^-13 inch (10^-14 m) across – just ten thousandths of the size of the atom. If the innermost shell of the atom was the size of a soccer ball, the nucleus would be the size of a ping-pong ball in the middle. (See right.) Put another way, if the whole atom were the size of a football stadium, the nucleus would be no bigger than a pea placed in the center of the field.

Protons and neutrons are about 10^-13 inch (10^-14 m) across and have a mass of about 1.67 x 10^-24 pound (7 x 10^-24 kg). Electrons are much smaller and have a mass only about 1/1836 of that of a proton.

One simple and obvious result of atomic structure is static electric effects, like the tingle you sometimes get when you take off an acrylic sweater and the way your dog hair can stand on end when combed. Because the outermost electrons are far from the nucleus, they are held in place only weakly and are apt to get knocked off. As you drag the sweater over your head, some electrons are knocked off atoms in the sweater and are drawn to the other surface. Our surface has more negatively charged electrons than the other. The two surfaces are drawn together by the opposite charge, and the charge is balanced out by a spark, which electrons flow.

Experiments have shown that there are more than 70 different subatomic particles. Only three, though, have any significant effect on the way materials behave, so chemists work with a model of the atom made of these three.

At the atom’s heart is a dense nucleus made of two kinds of particles, protons and neutrons. Protons have a positive electrical charge; neutrons have none. Whizzing around the nucleus are much smaller negatively charged particles called electrons. Most atoms have identical numbers of protons and electrons, so the electrical charges balance each other, making atoms electrically neutral.

Atoms can be split, but they are usually bound together by three forces. Negatively charged electrons are held in orbit around the nucleus by their electromagnetic attraction to the positively charged protons. Protons and neutrons are bound together in the nucleus by strong and weak nuclear forces. With gravity, these three forces make up the four forces of the universe.