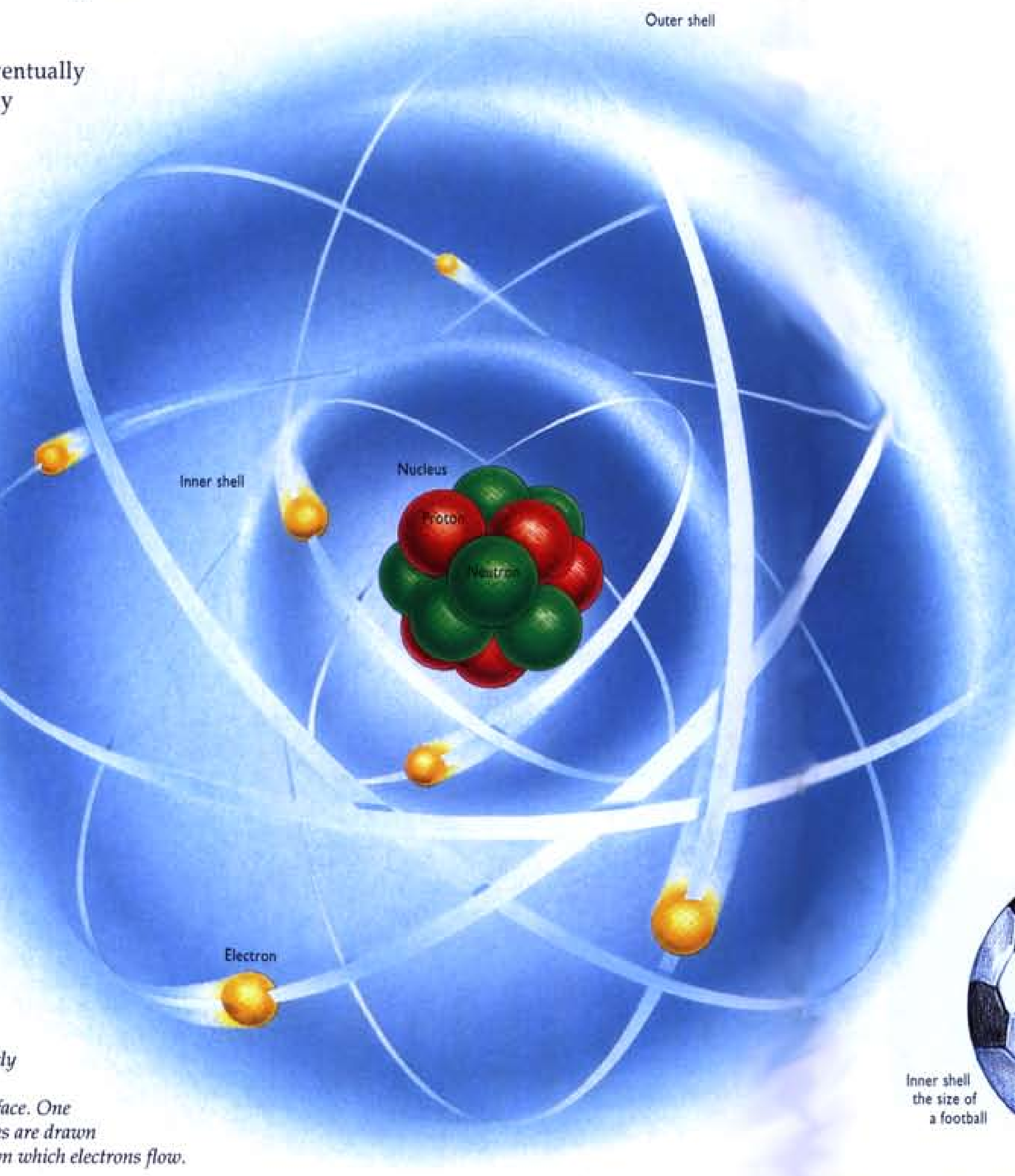
Inside the atom

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 atom, 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 *atomos*, 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 an 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.

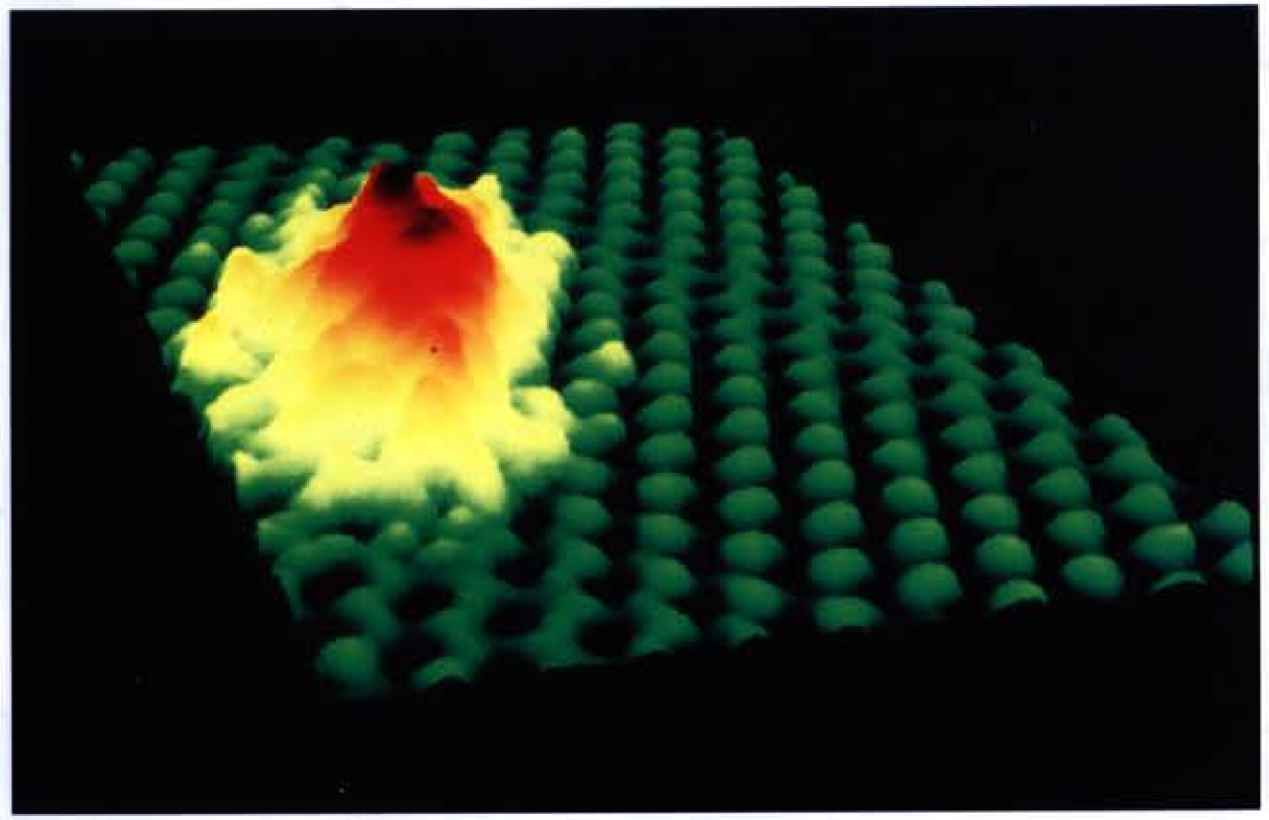


***The model of the atom accepted in the 1990s** has a dense nucleus with electrons orbiting around it in various layers, called shells. In the nucleus of all atoms except hydrogen, there are both protons and neutrons.*

*The nucleus is actually minute compared with the space occupied by the atom. In 1911, 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 pinhead lost in the middle (**far 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^{-15} m) across and have a mass of about 13.7×10^{-27} pound (7×10^{-27} kg). Electrons are much smaller and have a mass only about 1/1,836th that of a proton.

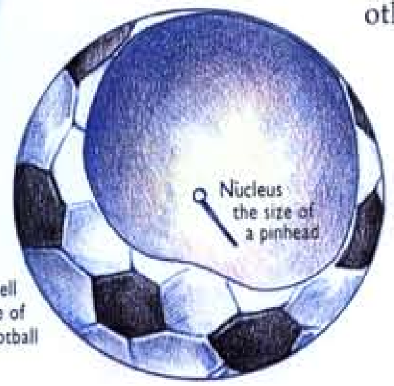
One simple and obvious result of atomic structure is static electric effects, like the tingle you sometimes get when you take off an acrylic sweater and the way dry hair can stand on end when combed. Because the outermost electrons are far from the nucleus, they are held in place only weakly and are 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. One 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, down 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.



Inner shell the size of a football

***Atoms can actually be seen.** The best pictures of atoms are taken by scanning tunneling microscopes (STMs), developed by IBM in Zurich, Switzerland, in 1981.*

*This STM image (**above**) shows gold atoms deposited on a base of carbon atoms. The gold – shown as yellow, red, and brown – forms a layer just three atoms thick on top of the carbon atoms which are in the form of a layer of graphite.*

STMs work by exploiting the difference in electrical charge between a special needle and the atom surface to create a picture of the atom like a contour map. The electrical difference causes a current to flow, but the strength of the current varies according to the position of the atom. So as the needle scans back and forth over the atom's surface, the microscope records these variations to create a map of the positions of the atoms.

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