Pearson

12.1: Friday Night Experiments: The Discovery of Graphene

In 2010, Andre Geim (1958–) and Konstantin Novoselov (1974–) were awarded the Nobel Prize in Physics for the discovery of a new material—graphene. **Graphene** is the thinnest material ever known (only one atom thick); it is also the strongest. It conducts heat and electricity, is transparent, and is completely impermeable to all substances including helium. Although its many possible applications are yet to be realized, graphene may one day be used to make faster computers, foldable touch screens, ultrathin light panels, and super-strong plastics to construct satellites, airplanes, ships, and cars. How did these scientists discover this wonder material? Through *Friday night experiments*.

Most successful modern scientists work in a narrow field of study, chipping away at a problem that they are experts at and know intimately. Andre Geim also worked this way—but not all of the time. Geim often ventured into what he calls *lateral ideas*. Lateral ideas are explorations into fields far from Geim's immediate area of expertise. Over 15 years he explored about two dozen such ideas. These explorations became known as *Friday night experiments* (even though they took much longer than just one night). Most Friday night experiments were complete failures, but some succeeded. For example, in one Friday night experiment, Geim was able to suspend an entire frog in a magnetic field. In another, he developed a new kind of tape designed to mimic the toes of a gecko. And Geim's most successful Friday night experiment led to the discovery of graphene.

In 2002, Geim assigned a brand-new graduate student a Friday night experiment as a way to give him time to get acquainted with the laboratory. The student's assignment was to make films of graphite "as thin as possible." The graduate student tackled the task by attempting to polish a tablet of graphite down to almost nothingness. In spite of his best efforts, the thinnest sheet he could craft with this method was still pretty thick (about 10 μm). In a breakthrough moment, a colleague brought Geim a piece of scotch tape that had been adhered to a graphite surface and then removed. The tape had remnants of graphite stuck to it. When Geim examined the graphite flakes under a microscope, he realized that these flakes were much thinner than those his graduate student was able to produce through polishing. In fact, some of the flakes were just one layer thick!

Over the next several months, Geim and his colleagues were able to isolate these flakes and measure some of their properties. In 2004, Geim and his colleagues published their results—the discovery of atomically thin carbon—in *Nature*. In 2010, Geim and his closest collaborator on the project, Konstantin Novoselov, were awarded the Nobel Prize in physics for "groundbreaking experiments regarding the two-dimensional material graphene."

Graphene has been right under our noses for some time. Every time you write with a pencil, layers of graphite flake onto the paper, leaving the familiar gray trail. That trail undoubtedly contains flakes of graphene—too small to see. Geim and Novoselov were able to see what others had missed and, as a result, discovered a new wonder material. These kinds of discoveries often have huge impacts on society—although it may take decades to realize and refine their applications.

In this chapter, we look into the world of solids and materials and see how they permanently changed societies, just like graphene may someday change our present society. For example, the discovery of cement led to a revolution in building, the discovery of porcelain led to a revolution in dishware, and the discovery of semiconducting materials made possible the computer and Internet revolution, which is still unfolding today. The development of new materials continues to be an active and growing area of research. We begin by examining a technique to determine the structure of solids.