Move over adamantium: The rise of graphene

A newly found form of carbon may change the study of nanostructures and your iPod.

Wolverine's skeleton is covered in adamantium. Captain America's shield is made of vibranium. Very soon, super heroes will be using another substance when creating indestructible tools and suits of armor. They'll be using graphene. What makes graphene better than adamantium or vibranium? Graphene is real. The 2010 Nobel Prize in Physics was recently awarded to two Russian-born British scientists, Andre Geim and Konstantin Novoselov, for their work in demonstrating the properties and potential of this carbon allotrope.

An allotrope is a pure, but structurally unique form of an element that both retains that element's essential properties and has unique traits. Carbon has more allotropes than any other element, including two with which most people are familiar: diamonds and graphite. Diamonds and graphite are both made of the exact same element, only structured differently. One gives sparkle, the other dull gray. Graphene is an allotrope that has only recently been discovered. Scientists recently predicted that it would be there, but had no way of studying it.

The reason it was impossible to study is that graphene is small, tiny even. Graphene is a single layer of carbon atoms arranged like chicken wire or a honeycomb in which each cell has six sides. Being so thin and flat is one of the reasons graphene is so unique. So thin is graphene, that when awarding the Nobel Prize, the academy called it "two-dimensional."

In an article for Nature written by Geim and Novoselov themselves, they address just how many layers of such a thin sheet it would take to be considered 3D. Their experiments showed that graphene can be considered three-dimensional at 10 layers. Any structure over 10 layers would have to be considered graphite.

In order to isolate graphene for study, scientists had been using all of the most high tech...
Doctors Andre Geim (left) and Konstantin Novoselov were able to isolate graphene. Doctors N M R Perez and Ricardo Ribeiro, in the New Journal of Physics, call the process of original isolation of graphene "simultaneously surprising and ingeniously simple on the surface."

What they found was a highly conductive, transparent allotrope of carbon that just happens to be the strongest (measured) material on earth. Just how strong is "strongest?" Research scientists at Columbia University’s Fu Foundation School of Engineering and Applied Science decided to measure just that. Using a very small piece of an already small material, they were able to determine that graphene is “some 200 times stronger than structural steel,” and “would take an elephant, balanced on a pencil, to break through a sheet of graphene the thickness of Saran™ Wrap.”

The study of graphene is not just important because of the way it was isolated using what is called the exfoliation method, but because graphene has so many potential uses. Perez and Ribeiro cite "radiofrequency devices, non-volatile memories, transparent electrodes in solar cells and liquid crystal displays" as products for which graphene is already being researched. Liquid crystal displays are a good example of how graphene could change many of the products you already own. Imagine dropping your flat-screen television or your mp3 player and not having to worry about the screen breaking. This is the potential graphene.

As electronics continue to shrink in size, silicon transistors have been finding limitations on just how small they can be. Because of the simplistic structure of graphene, it should be able to be used in the fabrication of much smaller transistors than silicon. Even better, the conductivity as measured by a report published in The International Journal of Carbon, shows graphene to have "the largest ever reported value for a semiconductor or a semimetal," making it a promising actor in the post-silicon era." These electronic wonders may be exciting, but for them you will have to wait. Geim and Novoselov don't believe that graphene research will be ready or that mass production of it will be practical or cost-efficient enough for those advances for another 20 years.

A little over 70 years ago, according to Geim and Novoselov, researchers Landau and Peierls argued that "strictly 2D crystals were thermodynamically unstable and could not exist." Although Landau and Peierls were incorrect, the practical uses of graphene are still years away. That such a material does exist, however, opens the door for a new generation of electronics and building materials about which many articles will fill this magazine.