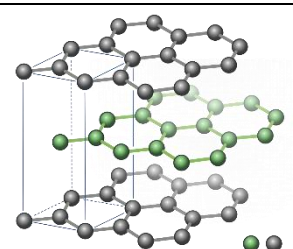




Stories of Science: Graphene

The story about how a chance discovery that might change world.

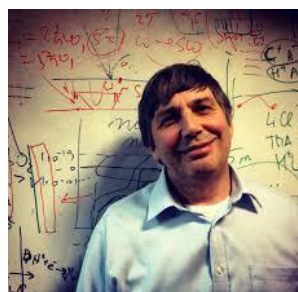
Graphite is a naturally occurring allotrope of carbon, other allotropes of carbon are diamond and fullerenes which are also made only of carbon atoms, but in each case the pattern with which carbon atoms are bonded with each other is different. In graphite, each carbon atom is bonded to three other carbon atoms forming a planar (flat) structure of hexagons. The fourth valence electron of each carbon atom is delocalised within the flat hexagonal lattice and allows graphite to conduct electricity. The layers have weak forces between them which means a few layers can be easily rubbed off by friction, such as when pushing a graphite pencil against a sheet of paper.



Graphite structure

Theory of a single Layer of Graphite

The ability of graphite to leave a mark on a piece of paper is what gave the substance its name (from the ancient greek *graphos*, to write), and graphite has been of particular interest to scientists thanks to its unusual properties as an electrically conductive non-metal. The layered structure was identified by X-ray diffraction in the 1910s and in 1947 P.R. Wallace proposed that a single layer of graphite might be able to conduct electricity. However it took over 50 years for scientists to isolate single layers of graphite and confirm Wallace's theory.



Andre Geim

Andre Geim

Andre Geim is a Russian-born physicist of German heritage. He studied physics at Moscow Institute of Physics and Technology, but only after twice being rejected from Moscow Engineering Physics Institute (according to Geim, because he was not an ethnic Russian), where he would have preferred to study particle physics rather than solid-state physics. He went on to hold research positions in labs in Nottingham, Bath, Copenhagen and Nijmegen. It was whilst in Nijmegen he did a "Friday Night Experiment" that would win him an Ig Nobel Prize.

Ig Nobel Prize

Geim has always believed in trying out slightly crazy things, and after reading about the very weak magnetic properties of water, one evening he cranked his lab electromagnet up to maximum and noticed he could suspend small droplets of water in the magnet. He then wondered if he could levitate a small aquatic creature in the drop of water, and chose a small frog, and to his surprise he was able to levitate the small frog which remained unharmed. Geim won the 2000 Ig Nobel Prize for Physics for his levitating frog. The Ig Nobels are awards that have been issued since 1991 for trivial or unusual achievements in science that make people laugh.

Discovery of Graphene

Geim left Nijmegen to move to The University of Manchester in 2001. There he worked with Konstantin Novoselov and a Chinese student named Da Jiang on a new "Friday Night Experiment" trying to isolate graphene sheets. Novoselov and Geim asked Jiang to polish a piece of Graphite down to around 10 μm using a special machine. They would polish Jiang's samples with sticky tape to clean them before looking at them using scanning tunnel microscopy. One evening they decided to investigate whether any Graphene had been left of the sticky tape, and fetched a piece from the bin and put it under the microscope. The tape contained graphite far thinner than Jiang had managed to make using the special machine. It wasn't quite graphene, but pulling more layers off with more sticky tape they were soon able to isolate single layers of graphene.

Nobel Prize

Geim and Novoselov won the Nobel Prize in Physics in 2010 for their discovery of graphene. There was discussion over whether UK, Germany or Russia could claim the Nobel Prize for their country, though Geim has always been clear that he considers himself European. Each scientist was rewarded by the UK government with Knighthoods, and by their university with car parking spaces closer to their building. Geim was the first, and to date, only scientist to win both Ig Nobel and Nobel prizes. He is a passionate about his "Friday Night Experiments", when crazy but interesting things are tried out. These experiments have brought about a levitating frog with no real-world applications, and the discovery of graphene, a two-dimensional material stronger than steel, more conductive than silicon the full applications of which are only limited by the imaginations of researchers to come.



Comprehension and Reflection Questions

1. Name all the allotropes of Carbon, write a definition of "allotrope".

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2. Describe the bonding of carbon in graphite and explain how it can conduct electricity.

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3. What does the word root "-graph" mean? Can you think of 5 scientific words that contain the ending "-graph(y)", what does each word mean?

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4. The line between discoveries and inventions is often blurred. Do you think Graphene was invented or discovered? Justify your answer

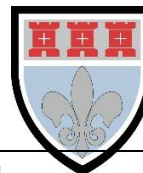
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Extension Activities

Ideas for things to do next:

Research some of the potential applications of graphene. Which ones do you think will have the biggest impact on your lives in future?

Can you think of any "Friday Night Experiments" you'd like to do if you had access to university research facilities? Do you have any "I wonder what would happen if..." questions?

Further Reading

Ideas for things to read next:

Andre Geim's Nobel Prize lecture (video)

Slate: The Deliberate Amateur

Guardian: Graphene The New Wonder Material