A visitor's review of Manchester's graphene exhibition

By **Tal Fox**

You may have heard the phrase, "the pen is mightier than the sword" but it turns out that the pencil is even mightier.

In 2004, two researchers from The University of Manchester, Andre Geim and Kostya Novoselov, managed to isolate a single atomic layer of carbon called graphene using a standard graphite pencil and a bit of cheap, everyday sticky tape. Ever since, scientists have been fascinated with this new material. Made up of a single layer of carbon atoms, graphene is 200 times tougher than steel yet completely invisible to the human eye. It offers a lot of potential for future applications that can revolutionize daily living.

Staying close to home, Manchester's Museum of Science and Industry opened their *Wonder Materials: Graphene and Beyond* exhibition to include the public in the story of graphene and to show them where it could lead in the future.

For someone who has not set foot in a laboratory since high school, the idea of having to wrack my brain for the last remainders of my limited science knowledge seemed intimidating, so I armed myself with a biomedical student scientist companion (it was the closest I could get to a materials scientist) and headed over to the museum to learn about graphene. The exhibition's associate curator, Sarah Baines, put my mind at rest when she told us: "Our expertise is very much in making science accessible."

The exhibition is filled with fascinating models, photographs, and short films and even offers a chance for visitors to get involved toward the end in "The Hive," which is a learning space often used for school groups. Ultimately the aim is to get visitors thinking, "How will graphene affect my life?"

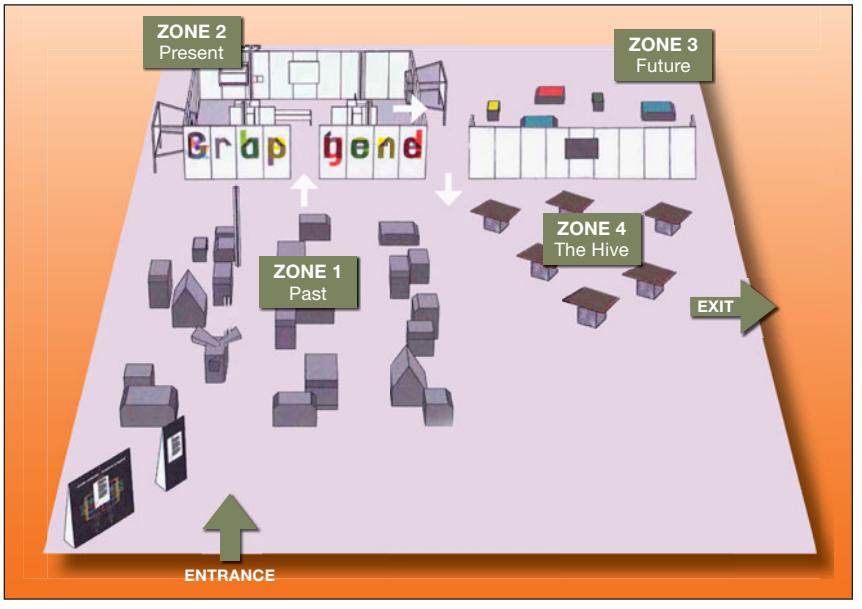
Sarah told us that they faced two major challenges in setting up this exhibition. The first was how to appeal to visitors ranging from the greatest graphene enthusiast, the teenager deciding whether to take the science path, and all the way down to those whose only connection to graphene is holding a pencil. The other challenge was: How do you make an exhibition about a material that you cannot see?

The exhibition is split simply into past, present, and future and proudly boasts about graphene's Manchester roots. Visitors are led through the museum starting with an introduction to the brains behind the discovery. They then learn about the scientists and artists who have continued to explore this cutting-edge material and its practical potential. Visitors conclude their tour "in the future" where graphene is making an impact on a multitude of industries, from medical science to mobile phones.

One of the key elements throughout is to show off the personalities of all those involved. The first display introduces us to Geim and Novoselov, who received the Nobel Prize for isolating graphene. Both scientists like to keep the creative spark alive in their research, which led them to hold frequent "Friday night experiments" where they would focus on experimental science not linked to their day jobs.

During one of these Friday night sessions, they used standard sticky tape to remove some graphite from a pencil and noticed that parts of the graphite looked thinner than others. Like any good scientist they tested this several more times to make sure that they could recreate the thin graphite flakes. This is the first time graphene had been isolated.

The pair like to keep a fresh and playful approach to their work, a theme which is also carried out throughout the exhibition. "Andre likes to call it 'search,' not 'research,'" Sarah tells us and it is that kind of humor that makes Andre the only scientist to have been awarded both the Nobel and Ig Nobel Prize for his witty approach to his "search," receiving the Ig Nobel Prize in 2000 for his work on levitating frogs. Yes, you read that correctly.



Schematic of the exhibition, *Wonder Materials: Graphene and Beyond*. Credit: Museum of Science and Industry in Manchester, UK.

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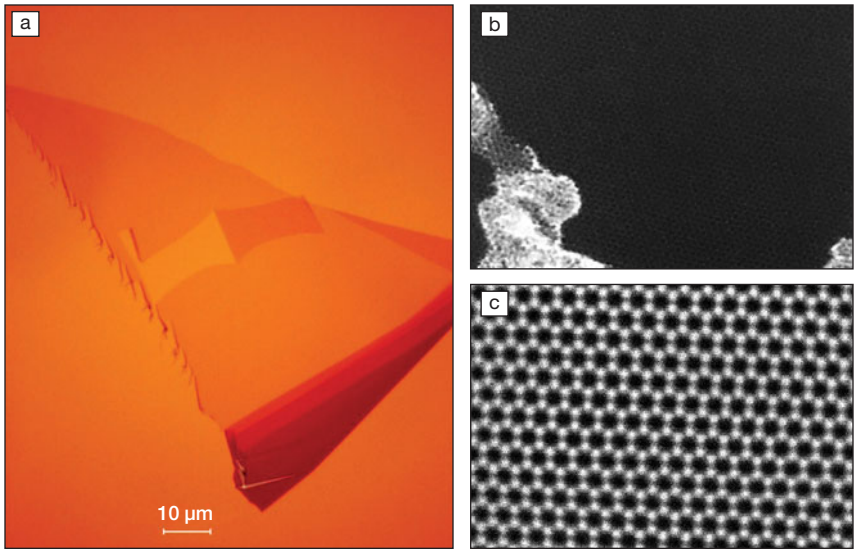
One of the first displays shows what graphene looks like magnified at three different scales (pictured right). The first one (a), magnified 100 times, looks like a slice of pizza. When zoomed in a little further, we can see small clusters of graphene (b). Zoomed in even more (c), the hexagonal atomic structure of the material becomes visible down to each white spot showing a single carbon atom.

That is about as complicated as it gets in the museum as most of the content shows graphene through music, sculptures, poetry, and all sorts of artistic creations made by people who were inspired by graphene. A dialogue between science and art is really at the heart of the exhibition.

We are told, "It's showing that visually people have had to show creativity and imagination to get to grips with what's going on at that super tiny scale." There are three short films in this section; the first shows how sticky tape was used to isolate a layer of graphene, the second is an introduction to "the wonders of graphene." If you are still caught up on the levitating frog, the last video shows the experiment so you can see it with your own eyes.

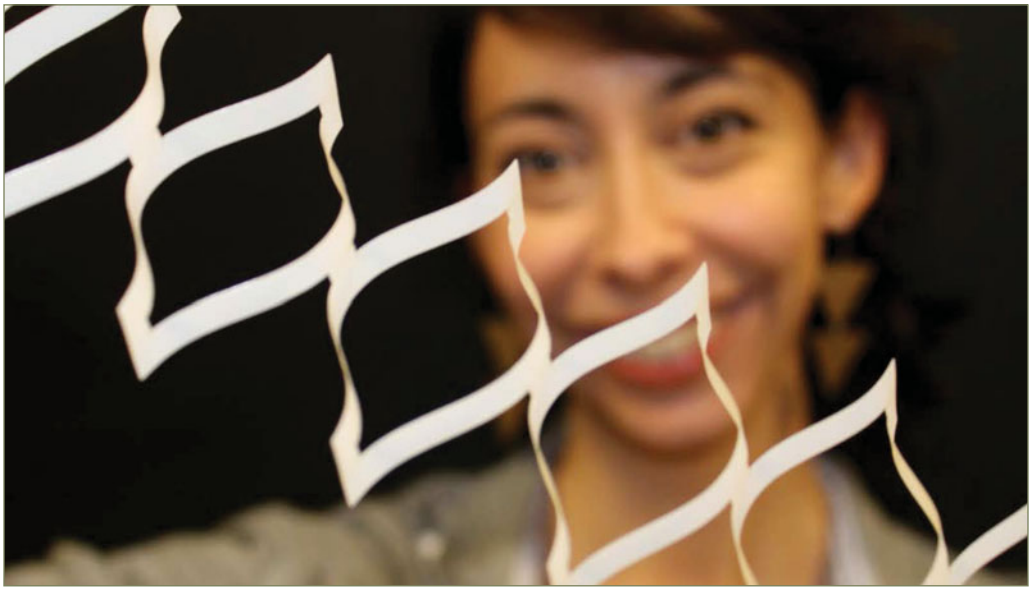
There is a model of a ship which Sarah jokes is partially because they just wanted an excuse to have a model of a ship, but mostly to show how graphite has actually been used long before Andre and Kostya discovered it. Graphite can be dated back 500 years to the Elizabethan era, where it was used to line molds for making cannon balls since this resulted in rounder and smoother weapons that could be fired farther. This new method helped strengthen the British Navy at the time.



(a) Credit: Image courtesy of Colin Roberts Wood, The University of Manchester; (b,c) Credit: Image courtesy of Sarah Haigh, The University of Manchester and Quentin Ramasse, EPSRC SuperSTEM Laboratory, Daresbury.

This part of the exhibition is dimly lit both in order to conserve the material but also to create drama as we leave behind the past and enter the brightly lit present. The present takes us away from the early findings of graphene and into current times where scientists have started to find real-world applications for the material. Sarah tells us that research is moving so rapidly that she can already think of six new examples to add to the exhibition.

In the center of the room there are a bunch of lockers, each one representing one of the graphene researchers involved. Each scientist's locker includes personal images and items as well as research objects and short videos about their projects. "We've introduced a bit of personality," Sarah says. "That's really important to us because we don't want people just to think that science comes out of nowhere; it's real people with a story."



Credit: Dr. Melina Blees of the McEuen Research Group, Cornell University, USA.

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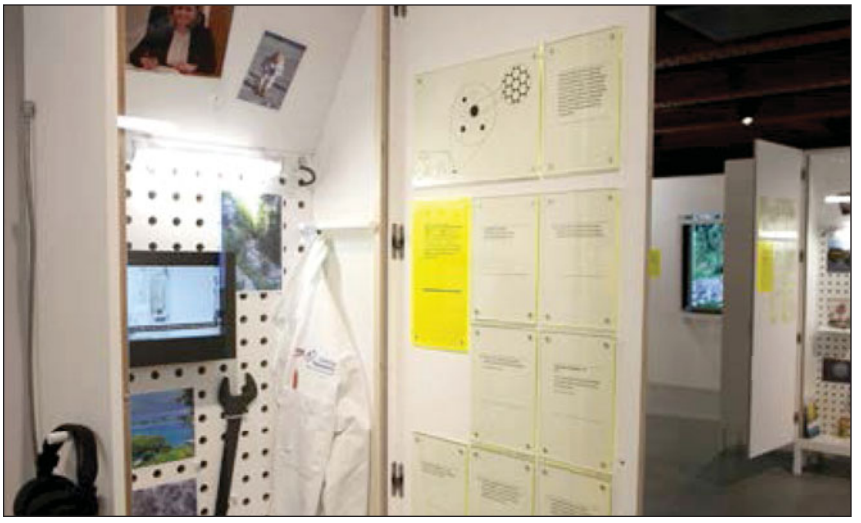

Credit: FGV Cambridge Nanosystems locker.

One of the more surprising lockers belongs to a researcher, Melina Blees, whose background is somewhat unusual. She has a PhD degree in physics but always had an interest in the arts, too. Melina is currently working as a science director for a theatre company, allowing her to weave between her two passions. Melina had wondered: If graphene is a sheet and paper is a sheet, will they actually behave the same way? It turns out they do, so she used robotic manipulations to interact with the graphene sheets and show how they can be folded and crumpled like a sheet of paper using an artistic technique called kirigami.

Melina says her locker is filled with objects that had been on her desk while working on the project, items that inspired her to think creatively and photos of her family. However, the most interesting item may be Dorothy L. Sayers's *Gaudy Night*, a detective novel she read when she started graduate school. "[The] book is specifically about academia and intellectual proof and the challenges of being true to yourself and being true to your work and the quest for truth that drives academia," she tells me. "I have a quote tattooed on my arm: 'Let's go now and have the truth at all hazards.' It's actually the tattoo I got to celebrate graduating," she says.

Melina works hard at making the science world seem accessible for anyone with an interest in science, which makes her contribution to the exhibition all the more fitting. "Recently there was a study that came out that said that girls aged 3 or 4 are less likely to think that women are brilliant. That's very young to be losing girls who are great scientists; that's incredibly sad if they think only people who are brilliant can be scientists and only men are brilliant—there's two levels of untruth there," Melina says. She also reaches out to minority groups who are being "fluffed out" of science at various stages. "I really want people to know that you don't have to be born to [science], you don't even have to be a professional but you can just be interested," she adds. By reaching out to students, doing interviews and workshops, Melina hopes to open up the science community to anyone who wishes to be involved.

As we headed to the final part of the exhibition, the future, I asked Melina where she hoped graphene was headed. "I think tiny robots are something that I would love to have," she says. "It's going to prove to be really valuable, but we need to do the research to see that it won't hurt people."

Sarah takes us into the future where graphene is being used to make three-dimensional printing filament, sensors, experiments on living cells outside of the body, and airplanes and cars that use less energy. But visitors are encouraged to dream even bigger with the wackiest ideas they can imagine.

"We want people to leave open-minded about where it will go," Sarah explains as she leads us to a wall at the back of the exhibition covered in colorful post-it notes. Several inventive visitors have noted their ideas for graphene to be used to cure all illnesses, but one orange square sticks out with the author's imaginative idea for a shape-shifting suit. Another reads: "A robot me that goes to work whilst I play games." There are suggestions for implants in the brain that communicate with our devices, and drinkable seawater through a graphene filter straw. There are also ideas for smart fabric clothes which can test for medical issues, and a flying backpack.

Returning to a more realistic approach Sarah tells us, "Loads of PhD students are wanting to get into it because it is so open-ended. It's not one of those areas in science where you think 'oh someone's already thought about that'; it's really quite fresh and open." "We hope throughout the exhibition people have a sense of what the properties of graphene are and what its potential might be," Sarah says.

Finally Sarah takes us to The Hive where my companion sits beside a young graphene enthusiast and gets stuck in with building his own atom structures with colorful, plastic slides that fit together to build the hexagonal shapes we saw in the first part of the exhibit.

As we left the museum my companion and I discussed how the exhibition had clearly managed to fulfill its objective of appealing to a wide audience from the scientist newbie to the keenest enthusiast. The 2D world of graphene had been turned into a 3D experience for us and the creative and artistic approach kept us alert and engaged at every stage. We both left feeling immersed in the world of graphene and curious to see where this material may next pop up in our lives.

The exhibition closed in Manchester in early summer, embarking on its international tour where it will next be shown at the Hong Kong Science Museum (December 15, 2017–April 18, 2018). Returning to the UK, the touring exhibition will eventually land at the Science Museum in London, in September 2018, ready to reveal the secrets of graphene to a brand new audience. □

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