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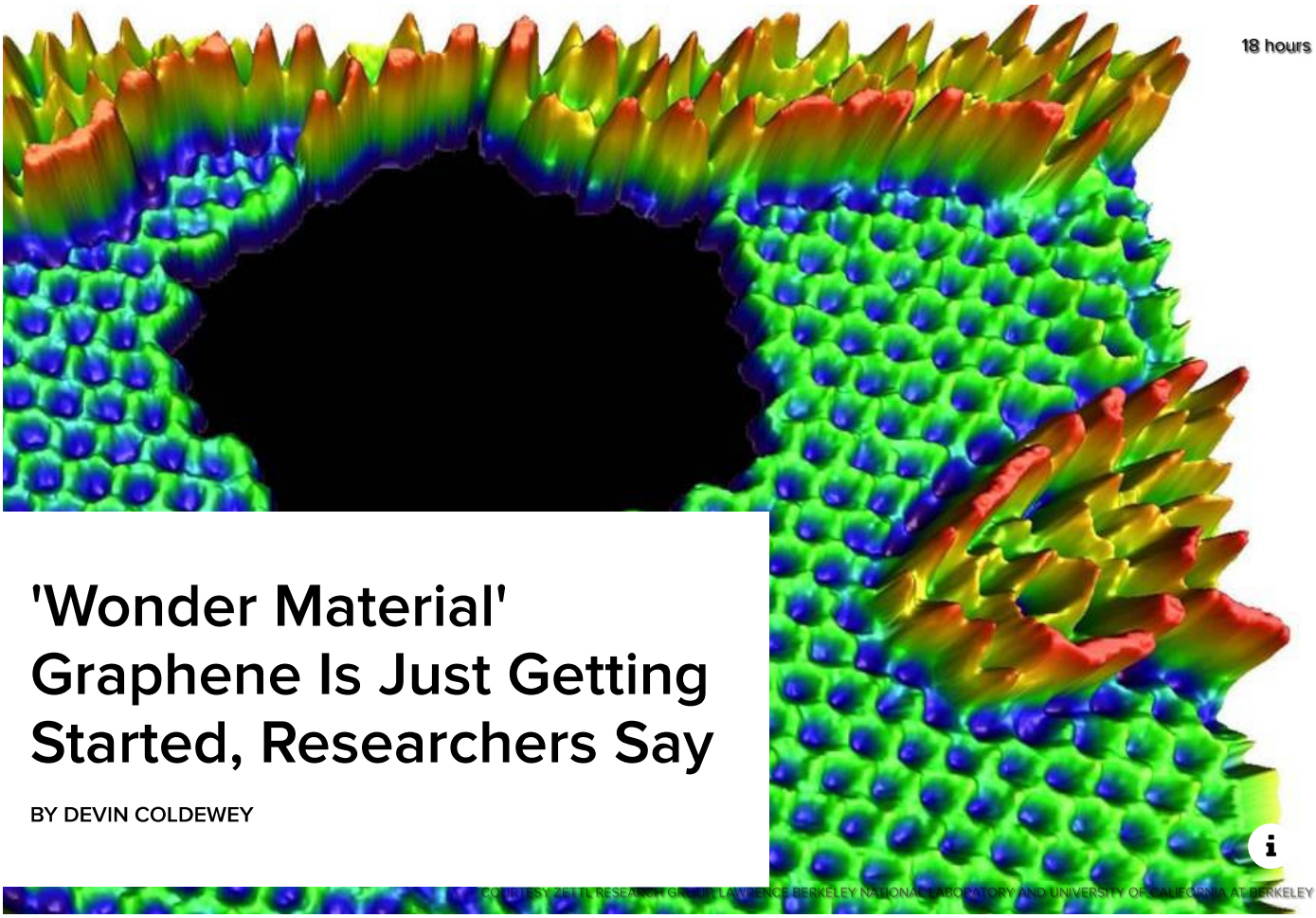


'Wonder Material' Graphene Is Just Getting Started, Researchers Say

BY DEVIN COLDEWEY

It makes batteries charge faster and last longer. It can detect light better than the best sensors. It could lead to flexible, impossibly thin touchscreens, super-strong composites and implantable electronics. It's called graphene, and although physicists have known about it for almost 70 years, it's only now that the wonder material is set to make a big debut.

Graphene, a lattice of carbon atoms so thin that it's referred to as "two-dimensional," is at the heart of dozens of advances in as many branches of technology.

"Almost every week there is a lab or university that has some amazing result or prototype," said Andrea Ferrari, graphene researcher at Cambridge University and chairman of the executive board at the European Union's billion-euro Graphene Flagship project.

Stretchable graphene electrode patterns transferred onto a silicon based polymer.

That's no exaggeration: In October alone, researchers showed that it could enable transparent, nontoxic brain implants, a powerful new tool for analyzing DNA, and stretchable batteries for use in flexible devices.

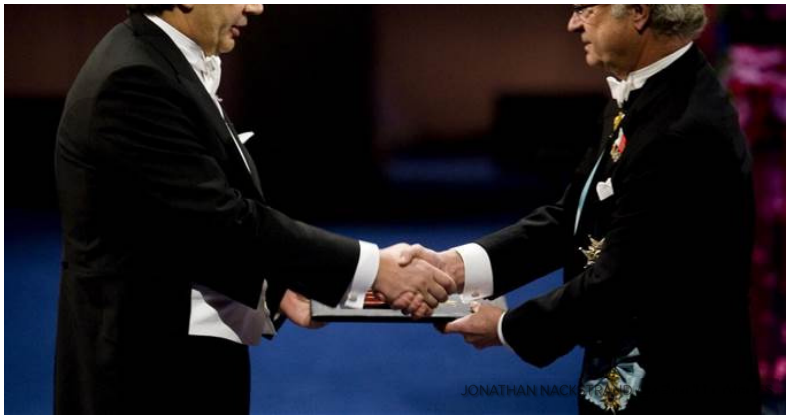
"There is such an array of interesting properties, and so many possible applications, it is almost a duty to investigate it," Ferrari said.

But perfect, unbroken, single-atom-thick sheets are the most difficult and expensive to create. The race is on now, not to find new uses for the material, but a way to make it without breaking the bank.

Old idea, new material

Graphene may be new to the average Joe, but physicists have long known about it — the flat honeycomb structure is a natural configuration that carbon atoms assume under certain conditions — like carbon fibers or "Buckyballs." In fact, the graphite we call pencil lead is billions of layers of graphene, a fact that led to a "eureka" moment in 2004.

Andre Geim and Kostya Novoselov of the University of Manchester managed to isolate a sheet of graphene simply by putting some graphite between pieces of Scotch tape and pulling it apart a few times. They announced this faintly comical (but effective) method ten years ago last month, and their follow-up work establishing a number of graphene's remarkable properties won them the 2010 Nobel Prize in



Dutch Professor Andrei Geim receives the Nobel Prize for Physics from King Carl XVI Gustaf of Sweden during the Nobel prize award ceremony at the Stockholm Concert Hall in Stockholm on December 10, 2010.

They also set off a veritable frenzy of studies as researchers tested the real-world properties of this long-theorized material. The possibilities multiplied:

"The great thing is it's like any other nanomaterial, you can tune it, you can change the dimensions of it — and on top of that, it's carbon-based," said Danielle Buckley, an expert in physical chemistry with the American Chemical Society. Many other useful materials are also toxic, building up in our bodies or in the soil when discarded — but carbon? We're made out of it!

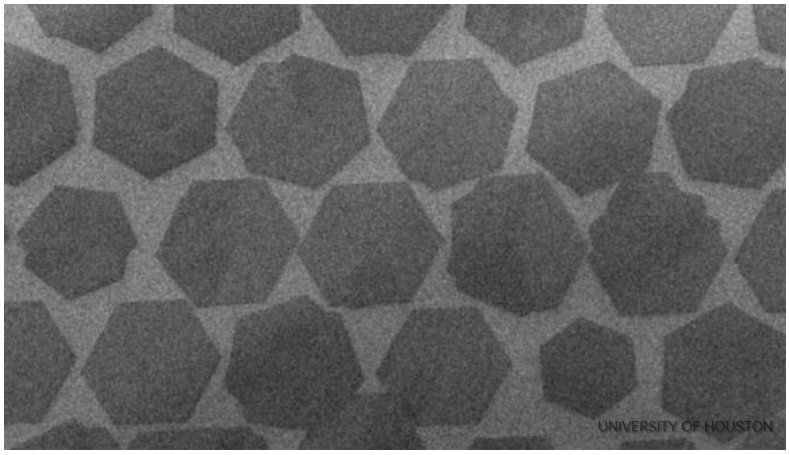
The trouble is that you can't meet global demand with pencil lead and scotch tape.

Supply and demand

"When a new material is being produced, it takes 20 to 40 years before it is in everyday use," explained Ferrari. "But the clock is ticking."

Graphene is facing growing pains just as every amazing new material does: it was a long time before nylon, polypropylene, kevlar, and carbon fiber were used anywhere but heavy industry.

Even now there are thousands of tons of graphene being produced, but there is no one best way to make it, as there



A scanning electron microscope picture of an "array" of smaller graphene pieces working together as part of a greater unit.

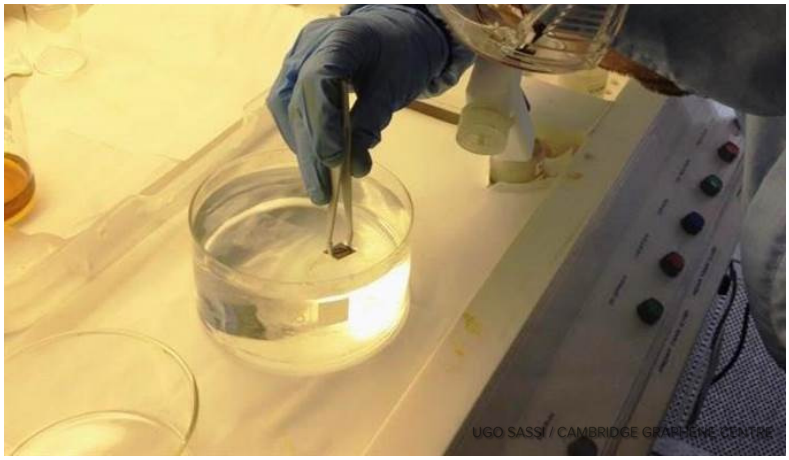
"You can do it chemically, or by putting some graphite in a liquid solution and using sound waves to break it apart, then there's what's basically a super-powerful blender," explained Buckley. Each method has its merits: speed, cost, volume — but also its drawbacks: small or flawed sheets, toxic byproducts.

Fortunately, even the tiniest bits of graphene can be used — recycled into larger patchwork pieces, suspended in a liquid to give it special properties, or used as a powder-like conductive coating. And a whole industry is being created from scratch to handle the material and its byproducts. One of the biggest projects attempting to get a jump on that is the EU's Graphene Flagship.

Flagship and beyond

"The Graphene Flagship is a ten-year program, and this week is the first year anniversary," explained Ferrari. A billion euros are scheduled to be doled out — a little now, more later as the industry becomes more established.

"By the end of the ten years, we hope to have products on the market," he said, likely first in strong, conductive polymers and then in advanced sensors.

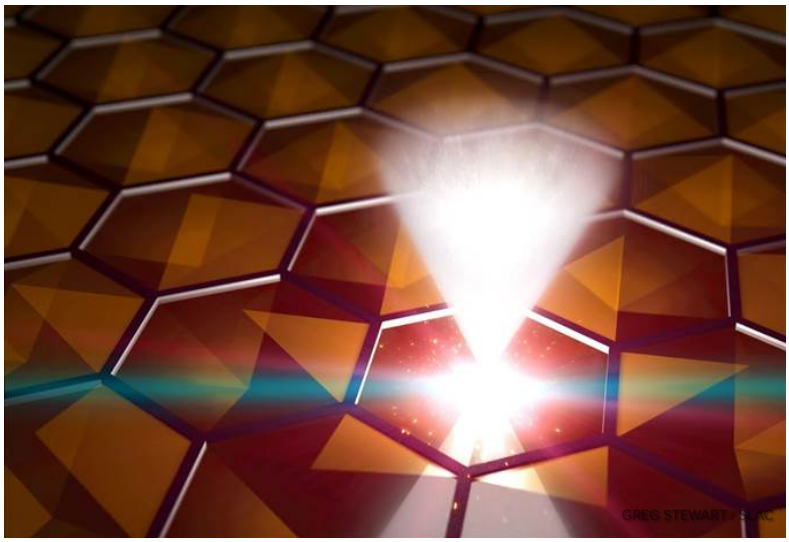


A Cambridge Graphene Centre scientist conducts a cleanroom experiment in which a single layer of graphene is transferred onto a substrate.

If that sounds like a long time, remember that graphene is still a baby, even compared to other nanomaterials. There's a lot of work to be done.

There are the challenges of competition and manufacturing as well as questions regarding long-term environmental and health effects — which the Flagship and graphene programs around the world are also investigating.

But even as they settle down to bring graphene to your living room, scientists are hard at work on the next next big thing.



Other nanomaterials may be commercialized before graphene, like cadmium arsenide, an artist's impression of which is shown here.

In other words, no matter how you look at it, we're just getting started.

"We don't want to claim that we're going to solve all of humanity's problems," cautioned Ferrari, "but we are in for a very interesting next ten years."

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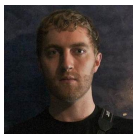

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