Nature Podcast

Introduction

This is a transcript of the 8th March 2018 edition of the weekly *Nature Podcast*. Audio files for the current show and archive episodes can be accessed from the *Nature Podcast* index page (http://www.nature.com/nature/podcast), which also contains details on how to subscribe to the *Nature Podcast* for FREE, and has troubleshooting top-tips. Send us your feedback to podcast@nature.com.

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Interviewer: Noah Baker
Hello and welcome to the *Nature Podcast*. This week we'll be hearing about graphene's latest superpower.

Interviewer: Benjamin Thompson
And, we'll be celebrating the 50th anniversary of a science fiction classic. This is the *Nature* Podcast for the 8th of March 2018. I'm Benjamin Thompson.

Interviewer: Noah Baker
And I'm Noah Baker.

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Interviewer: Noah Baker
Over the past decade or so, graphene is one of those things which we just keep hearing about. Physicists already call it a wonder material and now they think it might just have gained another potentially huge superpower. But before we get to that let's start with a quick graphene 101. Ben… what do you know about graphene?

Interviewer: Benjamin Thompson
It's a two dimensional material

Interviewer: Noah Baker
Correct! Made up of a single sheet of carbon atoms. Next question: how was graphene first isolated?

Interviewer: Benjamin Thompson
From pencil leads?

Interviewer: Noah Baker
Right again, sort of. It was first isolated from a layered material called graphite which you're right in saying is what you would find inside of a pencil. Have a listen to how Pablo Jarillo-Herrero from MIT puts it.

Interviewee: Pablo Jarillo-Herrero

We have plenty of materials which are layered. They look like a deck of cards, so to speak, and what people did not realise until about 12 years ago is that we could take one card from the deck and investigate its properties.

Interviewer: Noah Baker
And graphene does have some very interesting properties.

Interviewer: Benjamin Thompson
Yeah, I mean, I guess that as a one atom thick material it must be pretty weird?

Interviewer: Noah Baker
And it also makes for some pretty weird physics, in particular when it comes to its electronic properties. Here's Pablo again.

Interviewee: Pablo Jarillo-Herrero
The electronic properties of graphene are very unusual. They are unlike those of any other material. It seems like electrons in graphene behave like ultra-relativistic particles – particles that go close to the speed of light.

Interviewer: Noah Baker
Cool huh?

Interviewer: Benjamin Thompson
Yeah, but what is this new superpower you've been talking about?

Interviewer: Noah Baker
Ah yes, well for that I am going to have to hand over to reporter Lizzie Gibney who has been talking to Pablo about two papers that he and his team have published in *Nature* this week. Lizzie – take it away.

Interviewer: Lizzie Gibney
So graphene is already quite remarkable but you and your team have managed to find another property that it has which makes it even more exciting.

Interviewee: Pablo Jarillo-Herrero
When you stack graphene on top of each other with a very particular angle of rotation which theories have called the magic angle – it's about 1.1 degree of rotation – it turns out that this graphene system can exhibit superconductivity.

Interviewer: Lizzie Gibney
Okay, so what is superconductivity and why are people excited about it?

Interviewee: Pablo Jarillo-Herrero
Conventional superconductivity is a phenomenon where electrons are able to conduct through a material without dissipating energy. So, you are able to run an electrical current through a conductor to dissipate no power. So this is something which is very extraordinary.

Interviewer: Lizzie Gibney
So you discovered that graphene has this superconducting behaviour but it's not a conventional superconductor – is that right?

Interviewee: Pablo Jarillo-Herrero
Yes, most superconducting materials happen to be metals and then you cool them down, you cool them down, and at some point there is a superconducting transition. Many of the unconventional superconductors that we have are materials which are insulators at higher temperatures and then when you add this very small amount of charge to these insulators, superconducting transitions happen. Also, depending on how much charge you add to it, it changes the temperature at which this material becomes a superconductor and the graphene system we have created exhibits many of these characteristics that are common in unconventional superconductors.

Interviewer: Lizzie Gibney
So conventional superconductors tend to be metals and we think we understand how they work. These unconventional superconductors are much more complex. Do we know what's going on inside those? Are we able to explain them?

Interviewee: Pablo Jarillo-Herrero
There are different theories but there's no universal consensus on why these materials behave the way they behave. This is something that has been a long standing problem for three decades and that people haven't figured out.

Interviewer: Lizzie Gibney
And what implications does your study have then for trying to get to the bottom of this thirty year mystery about how these unconventional super conductors actually work?

Interviewee: Pablo Jarillo-Herrero
This system is graphene rotated on top of graphene. It's completely different from the chemical point of view, from the structural point of view, from any of these other unconventional superconductors, which in some sense tells you that some of the details of the chemistry, of the structure etc… are not essential in capturing the key or the basic physics responsible for superconductivity. That might be one option so perhaps there are some higher level elements or common elements or common physics at a higher level that is responsible for all of this.

Interviewer: Lizzie Gibney
And taking a look at the bigger picture then, these – when we talk about the superconductors – they are still below zero degrees Celsius but the aim of this whole field is that maybe someday if we understand them enough, we can push that temperature higher and higher. What would that mean if we were able to do that and where might your graphene system help us to get there?

Interviewee: Pablo Jarillo-Herrero
Increasing the temperature at which superconductivity occurs could have phenomenal technological implications. Just to give one example: about 20 to 30% of electricity, of the

energy carried by the electrical current is dissipated just in transportation of that electrical current from where it is originated to the ultimate destination. If we could have superconducting, transmission lines – wires – that would carry that electricity there would be zero dissipation. So right away you would gain… you know, again the estimates depend on exactly who you talk to and the country etc… but between 10 and 30% of the energy, you would get it back just by using superconductor transmission lines. What we hope is that our graphene system which for now has a relatively low critical temperature, what we hope is that it will help us understand that mechanism, what are the essential ingredients, how did you put them together in order to get unconventional superconductivity and hopefully this will help us design novel materials or the right conditions for a material to be changed in order to increase the critical temperature higher and higher.

Interviewer: Noah Baker
That was Pablo Jarillo-Herrero from MIT in the States speaking with Lizzie Gibney. You can read Lizzie's news story about superconducting graphene at nature.com/news where you'll also find links to both of Pablo's papers.

Interviewer: Benjamin Thompson
Later in the show, we'll be learning what the 2018 Canadian budget means for science. That's coming up in the News Chat. First though we're joined by Ellie Mackay – the newest member of our team – and she's brought the Research Highlights along with her.

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Interviewer: Ellie Mackay
Lactams are common chemical structures found in a whole host of drugs, from antibiotics to anti-tumour compounds. To make them scientists need to strip hydrogen from a chemical skeleton and replace it with nitrogen. This reaction normally uses a metal catalyst but there's no effective metal for making lactams because this particular reaction involves an unstable intermediate stage which causes the production chain to collapse. To overcome this hurdle, a team of scientists in Korea have created a custom catalyst made of iridium, one of the densest elements on the planet. By adorning this metal with lactam loving molecules, it can withstand those destabilizing central reactions. In fact, these efficient embellishments have already been used to create lactams from a range of complex compounds, suggesting the potential for more efficient synthesis of drugs in the future. For more on this speedier drug production, dash on over to *Science*.

[Jingle]

Interviewer: Ellie Mackay
Have you ever been caught out by a flat phone battery on a cold day? That could be because the lithium-ion batteries that power modern electronics are frustratingly feeble when it comes to frost resistance but now researchers in China have developed a new type of battery that retains charge even in temperatures as cold as minus 70 degrees Celsius. The solution: combining organic polymer electrodes with ethyl acetate, a solvent with an extremely low freezing point to act as the ion carrying electrolyte. Ethyl acetate retains enough conductivity at low temperatures that even the most sluggish lithium ions continue

to hold charge – as much as 21% at minus 70 degrees. And the new batteries return to full capacity when warmed back up, unlike normal batteries which may never fully recover after freezing this is a cool improvement on current, current supply and holds great potential for providing energy in super chilled environments such as space. Even better, the organic polymers are a potentially green alternative to conventional materials. The new battery is bulky so it might not fit in your pocket just yet but it may not be long until we can all enjoy a frosty reception. If you're feeling energized by that story, head on over to *Joule* for more.

[Jingle]

Interviewer: Benjamin Thompson
Now then Noah, before we continue, I would just like to ask you a question. You're watching television. Suddenly, you realize there's a wasp crawling on your arm. What do you do?

Interviewer: Noah Baker
What is this?

Interviewer: Benjamin Thompson
Nothing to worry about, sir, it's just called a Voight-Kampff test. I'm trying to judge whether you're an android or not.

Interviewer: Noah Baker
Well I'm not.

Interviewer: Benjamin Thompson
Well of course you would say that wouldn't you? Listeners, the Voight-Kampff test of course comes from the much beloved science fiction book *Do Androids Dream of Electric Sheep?*, published in 1968 and written by Philip K. Dick, one of the most enduring science fiction writers of the 20th Century. 2018 is the book's 50th anniversary, and this week in *Nature*, Ananyo Bhattacharya, a science correspondent at *The Economist*, has written a retrospective of the novel for our Books & Arts Section. Now, many people – myself included – are more familiar with the movie *Blade Runner*, which was based, somewhat nominally, on the book. I started by asking Ananyo for a brief summary of the plot, and listeners, even though this book is half a century old, I will give you fair warning that spoilers abound.

Interviewee: Ananyo Bhattacharya
So, the overall plot is similar in that it's about a bounty hunter, Rick Deckard, who is given the job of hunting down a bunch of androids. Now in the film that's pretty much the plot. In the book things get kind of weird and complicated.

Interviewer: Benjamin Thompson
Yeah, I mean in the first few pages we're introduced to artificial animals, the shared-empathy religion, Mercerism, and the Penfield dial-a-mood machine. Discerning the real from the fake then is very much a central theme of this book whether we're talking about moods or animals or the androids themselves.

Interviewee: Ananyo Bhattacharya
Philip K. Dick is really asking at what point do androids begin to share something of the humanity. At what point do we start treating them a bit more like humans?

Interviewer: Benjamin Thompson
And if something is so convincing as to be real then do you think it devalues what actually is real?

Interviewee: Ananyo Bhattacharya
I think that is Dick's point actually. I don't think the movie makes that so well and neither does the sequel. Unlike the film, the book is never really in any doubt that the androids, which are shortened to 'andies', the world word 'replicant' was actually made up for the movie. But 'andies' are not human. They lack empathy. So Dick's not actually in any doubt about that. He's actually much more concerned about the effect that robots that look and act quite a lot like us but are nonetheless still machines, what sort of effects they have on our psyche.

Interviewer: Benjamin Thompson
We're perhaps not quite up to the level of realistic androids yet but are there any other studies going on looking at the effects that anthropomorphizing current technologies is having on humans?

Interviewee: Ananyo Bhattacharya
Yeah, so, I mean there have been a few. One that recently caught my attention was this great study on digital assistance like Siri. Essentially they looked at the questions that people tended to ask and they found that for a significant minority, asking really simple questions to these digital assistants was a problem and it was a problem because they became embarrassed to look stupid in front of Siri and it's quite incredible when you think about it because these are really simple pieces of AI and if we're capable as humans of anthropomorphizing digital systems then how are we going to feel about robots or mechanical pets or anything that are very much more realistic. In essence I think we risk investing time and emotions into these sorts of machines with the danger that we're neglecting real things and real people.

Interviewer: Benjamin Thompson
So, 50 years on then, where does this book stack up? Where does, *Do Androids Dream of Electric Sheep?* stand in the pantheon of science fiction and broader fiction?

Interviewee: Ananyo Bhattacharya
To my mind, the influence of the book is just now becoming apparent. We're beginning to explore the potential of artificial intelligence. Barely a day passes with us not hearing about some new AI problem or solution. It looks like robots are getting more sophisticated and they will begin to enter our lives in a bigger way, perhaps. And I think, you know, we will look at this book again in another half century and we'll just marvel at how prescient it seems.

Interviewer: Benjamin Thompson

That was Ananyo Bhattacharya there, whose retrospective on Philip K Dick's novel can be found over at nature.com/news/booksandarts.

Interviewer: Noah Baker
And just for the record, listeners, I am not an android. Or am I? No I'm not. I'm definitely not.

Interviewer: Benjamin Thompson
Finally then this week, it's the News Chat, and I'm joined on the line from Washington DC by Jane Lee, News Editor for the Americas here at *Nature*. Hi Jane.

Interviewee: Jane Lee
Hi.

Interviewer: Benjamin Thompson
So first up today then we've got a story that just missed the cut off for last week's podcast but I think it seems like some good news for a lot of researches. Jane, maybe you could tell us a bit about it.

Interviewee: Jane Lee
Canada released its budget on February 27th and they included a lot more money for scientific research. They are giving them almost four billion Canadian dollars. That's about 3.1 in US dollars and that's in contrast to last year where they only got about a billion Canadian dollars of new science funding, so this is a big, big increase and so folks are very happy.

Interviewer: Benjamin Thompson
Oh my goodness so this really is a significant increase then. Who were the winners, Jane?

Interviewee: Jane Lee
The budget is targeted mostly at early career and young researchers so folks are very happy about that.

Interviewer: Benjamin Thompson
Well good news for them certainly. I mean, four billion dollars is a lot of money. Do we know how it's going to be split up?

Interviewee: Jane Lee
A lot of the money seems to be going to basic research, and so they're giving their granting councils hundreds of millions of dollars to distribute how they see fit. So, last year one of the criticisms of the budget was that money seemed targeted at specific projects and institutions or organisations but this year it seems like the government is giving federal agencies more leeway in determining who gets the extra funding.

Interviewer: Benjamin Thompson
And what changed the government's mind?

Interviewee: Jane Lee
So the researchers that we spoke to for this story seemed to think that it was this fundamental science review. It was a review that came out last year looking at the state of funding for science in Canada and came out with a list of recommendations and this 2018 budget seems to have followed a lot of those recommendations.

Interviewer: Benjamin Thompson
Well, what about the politicians? What do they say?

Interviewee: Jane Lee
Well the finance minister Bill Morneau in remarks to legislators on February the 27th, called the latest budget the single largest investment in investigator led, fundamental research in Canadian history. So, they're very excited about it. You know, when Justin Trudeau got elected and his government got changed over, I think people were really hopeful about what he could do for science and when he released his budget last year I think folks were fairly disappointed because they were hoping for more but I think this year they're much more pleased and hopeful and although they didn't get as much money as that fundamental science review recommended, they think that the budget's generally going in the right direction and I think people are hoping that they can sort of make up for lost time or lost budgets, if you will.

Interviewer: Benjamin Thompson
Alright then, Jane. Well let's change tack a little bit if you will. Our next story is about satellites. What's going on?

Interviewee: Jane Lee
Yes, so the United States just launched its recent weather satellite called the Geostationary Operational Environmental Satellite-17, or GOES-17. And they did that on March 1st and it's joining a twin satellite, GOES-16, which is already in position over the Atlantic Ocean and Goes-17 will be parked over at Equatorial Pacific and you know with both of those satellites up in the air now, scientists can look at weather phenomenon, as well as things like snow cover and wild fires from West Africa across the United States and down to New Zealand. So they've got a nice big picture of part of the earth. The problem though is that with this new satellite, it's great, it fills in a gap in some of the coverage, but it's also highlighting a challenge that weather forecasters and researchers have been grappling with for a long time and that's the fact that they actually can't use a lot of the information that these satellites record in their forecast models.

Interviewer: Benjamin Thompson
So that does seem like a bit of an oversight. If these satellites are collecting all this data, how can it be used?

Interviewee: Jane Lee
So they are starting to address this. The main problem was a technical problem – the way the satellites record this information, they can't easily translate it into data that the forecast models can use and so they've been chipping away at this for a while now. There's a European group who has been the leader in this for about 10 years and at research

universities here in the United States who are working on this and they are starting to fix it. There's one study that's in review right now at a journal showing that with this additional data incorporated into forecast models, it definitely improves things like tracking the early development of hurricanes or predicting how strong they'll eventually become. While the fixes to this problem aren't ready for primetime, you know, it's not being used in operational models yet, initial studies with experimental models are showing some encouraging results, so they're hoping in the near future that they can roll this out to the major forecasting centres and get them into the operational models that can tell people about weather and storms and such.

Interviewer: Benjamin Thompson
Thanks Jane. Listeners, you can read all about these stories and more over at nature.com/news.

Interviewer: Noah Baker
And that's it for this week. But before we go, remember our story from last week's show about the researchers who'd discovered signals from the cosmic dawn?

Interviewee: Judd Bowman
Astronomers had been looking for evidence from this time for probably over a decade or two decades.

Interviewer: Noah Baker
Well if you want to learn a little bit more about that, we have just the film for you in which Lizzie tries to cram in all you need to know about the discovery into just three minutes… 'ish'. Check it out at youtube.com/naturevideochannel. I'm Noah Baker.

Interviewer: Benjamin Thompson
And I'm Benjamin Thompson. Thanks for listening.

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