Nature Podcast

Introduction

This is a transcript of the 31st May 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: Shamini Bundell
Hello and welcome to the *Nature Podcast*. This week, we're finding out about a project that's boosting diversity in physics.

Interviewer: Adam Levy
Plus, life's recovery from a massive asteroid impact confounds expectations. This is the *Nature Podcast* for the 31st May 2018. I'm Adam Levy.

Interviewer: Shamini Bundell
And I'm Shamini Bundell.

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Interviewer: Shamini Bundell
With the recent royal wedding here in the UK, there's been a lot of discussion about whether our society truly is a meritocracy. In science at least, things are more clear cut than in the monarchy – professorships aren't handed down from generation to generation along with the crown and the right to own all the swans. In science, success is supposed to depend on an individual's personal merit - that's the idea anyway. In practice, academic ability is far from the only factor affecting a scientist's career. Ted Hodapp from the American Physical Society is concerned about the fact that in his field, physics, there's a clear imbalance in the kinds of students reaching both undergraduate and graduate level.

Interviewee: Ted Hodapp
About 35% of the US population can be classified as underrepresented minorities in the definition that we use, which is African Americans, Hispanic Americans and Native Americans. And 35% drops to about 11 or 12% getting bachelor's degrees for physics, and when you go on to the PhD it drops even further down to about 6 or 7%.

Interviewer: Shamini Bundell
In the US, affirmative action policies try to counter some of the effects of racism or other forms of discrimination in admissions. But direct discrimination isn't the only reason for the lack of minority students in physics. Structural inequality in society has a range of knock-on effects.

Interviewee: Ted Hodapp
There are a lot of different reasons why students don't advance between the bachelor's degree and the PhD. Although many of them are ready to go on to a PhD, many of them are not ready because they don't think they're ready, or they're given the wrong advice about how to prepare for and take a particular exam that is used in the United States called the Graduate Record Exam. And many physics departments use this very strongly to rank students.

Interviewer: Shamini Bundell
The use of tests such as the Graduate Record Exam, known as the GRE, and the use of the undergraduate grade point average, known as a GPA, is supposed to ensure that admissions officers can select the most capable students. But there are many factors that can influence these kind of test results, many of which are nothing to do with academic ability. Zack Hall, a physics graduate at the University of North Carolina at Chapel Hall was very keen to pursue physics after undergrad, but found that he wasn't in the best position to do so.

Interviewee: Zack Hall
My biggest issue was my undergraduate GPA was very low, and that wasn't a great indicator of my ability or my, I guess, drive to continue in physics. For me personally, undergrad was really, really challenging in more ways than just academic – both personally and financially. I think it's very easy for certain types of students to be completely dismissed when considering only these kind of standardised factors.

Interviewer: Shamini Bundell
Zack was able to gain his current PhD place thanks to support from the American Physical Society Bridge Program, of which Ted Hodapp is Director. The programme aims to get more students from underrepresented minorities into graduate programmes. One of the many ways it's doing this, is by encouraging university admissions to focus less on the results of standardised tests.

Interviewee: Ted Hodapp
One of the ways you can do that is by not looking at the GRE score to begin with, you look at all the other pieces. If you look at a low score on something before you rank a student in an application process, you automatically think more poorly of such a student - this is something called anchoring bias.

Interviewer: Shamini Bundell
When talking to graduate admissions departments, the APS Bridge programme encourages a more holistic approach, looking at the trajectory and potential of students.

Interviewee: Ted Hodapp
So a fixed mindset says let's just pick the individuals who are the stars of the pool here. And a growth mindset says let's pick people who we think can do amazingly well if we give them the right opportunities. And there's a big difference there, because if you didn't have the right opportunities to begin with to be able to show your potential, you're just not going to be selected.

Interviewer: Shamini Bundell
But there's more that can be done beyond just changing selection criteria. Here's Brian Zamarripa Roman, another student on the APS programme.

Interviewee: Brian Zamarripa Roman
When I realised that I had to pay for grad school applications, I was like oh, I don't know if I can do all that. You know, because like my mum didn't work, and my dad, actually my dad had passed away my junior year in high school. And so, growing up I had to pretty much take care of my family as well, and so there was a lot of things that I had to worry about, a lot of things that I didn't know. I knew that the end goal was a PhD, but I had no idea what steps to take.

Interviewer: Shamini Bundell
The Bridge Program helped Brian take the Graduate Record Exam and put in a graduate school application, despite having missed the normal deadline. He's now studying at the University of Central Florida, but the Bridge Program continues to support him through mentorship schemes. Ted Hodapp says that ongoing mentoring schemes are important, and he believes they may be responsible for the high retention rate of PhD students on the programme.

Interviewee: Ted Hodapp
Oftentimes I think physics programmes, there's a sense that once a student comes in, the faculty don't need to pay attention to the student, they say if they're good enough, they're going to continue and they're going to complete their degree. And it kind of ignores the fact that certain students are coming in not knowing how the system works.

Interviewer: Shamini Bundell
Students of the APS Bridge Program believe that it, and programmes like it, can have a wider benefit than just to the individuals involved. Michelle Lollie has been supported by the APS at Indiana University, Bloomington.

Interviewee: Michelle Lollie
It's important because, you know, we have to change the face of physics. There's a stereotype of, you know, an older Caucasian male being your standard physicist, so it's important for, you know, a little brown or black girl or young man, they have to see, you know, people who look like them. The advice I would give, if you really want to do it, do it because you love it and know that you can do it, and you may experience some challenges along the way, but you are changing the face of physics and history at this time, and that's what we need to have.

Interviewer: Shamini Bundell
Thanks for students Michelle Lollie, Zack Hall and Brian Zamarripa Roman for talking to us about their experiences. Ted Hodapp is Director of Project Development for the American Physical Society, and along with colleague Erika Brown, has written a Comment piece in this week's issue of *Nature*, about the APS Bridge Program. Find that at nature.com/nature/news.

Interviewer: Adam Levy
Still to come in this week's show, how life crept back after the asteroid impact that wiped out the dinosaurs…

Interviewer: Shamini Bundell
Clears throat

Interviewer: Adam Levy
Oh… sorry… the non-avian dinosaurs.

Interviewer: Shamini Bundell
Thank you.

Interviewer: Adam Levy
Phew. Now though, Ellie Mackay joins us in the studio for this week's Research Highlights.

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Interviewee: Ellie Mackay
Lizards and snakes, collectively known as squamates, are the largest group of reptiles. But a gap in the early fossil record, means that evolutionary origin is a slippery subject. Now, scientists have estimated the age of an ancient squamate fossil found in the Italian Alps. New high-resolution X-ray imagery revealed it's around 75 million years older than the earliest previously known of these scaly specimens. This helped the team put together the most detailed family tree of squamates yet. Together, this work fleshes out the fossil record and teaches us more about the early evolution of our slithery friends. Find that study in this week's *Nature*.

[Jingle]

Interviewee: Ellie Mackay
From historical snakes to old artwork, and a high-tech solution to the sticky issue of aging adhesives. Since the 1930s, sticky tape has been used to hold artwork in place in framing or storage. Even the 2000-year-old Dead Sea Scrolls have been taped together in places. But over many decades, the glue breaks down and can damage the artwork when it's removed. Now, scientists have developed a gel, containing nano-sized droplets of solvent. These can penetrate through the pores in the tape to dissolve the adhesive, without affecting the previous works attached. Get stuck into the paper at the *Proceedings of the National Academy of Sciences*.

[Jingle]

Interviewer: Shamini Bundell
How does an ecosystem recover after a disaster? Reporter Benjamin Thompson has been finding out how quickly life recovered after a cataclysmic event 66 million years ago.

Interviewer: Benjamin Thompson
Listeners, today's story begins at the end of Earth's Cretaceous period, when dinosaurs were roaming around, and the oceans and seas were teeming with life. Something was about to happen that would change everything.

Interviewee: Chris Lowery
So about 66 million years ago, an asteroid the size roughly of Manhattan Island, I think it was about 10 kilometres across, crashed into what is now the Yucatán Peninsula in the Gulf of Mexico, and caused the most recent mass extinction in Earth's history. It's responsible for wiping out the non-avian dinosaurs, as well as a lot of cool marine animals, and overall 75% of life on earth went extinct.

Interviewer: Benjamin Thompson
This is Chris Lowery from the University of Texas Institute for Geophysics. He's been looking at the enormous impact site of this asteroid, known as the Chicxulub crater, and my goodness, this asteroid left a big crater.

Interviewee: Chris Lowery
It was going something like, I don't know, like 20 times faster than a rifle bullet, it's moving insanely fast. And so, you know, you see all these pictures of like the dinosaurs looking up in terror as the asteroid streaks across the sky – that's not what it looked like. It probably would have been just like a white flash and that's it. But the asteroid hit, it caused big seismic disruptions across the Gulf of Mexico, you get slope collapse all around the Gulf of Mexico basin, formed a huge tsunami that washed all the way up, and I think as far up almost to Iowa you find tsunami deposits from the impact.

Interviewer: Benjamin Thompson
In a *Nature* paper this week, Chris and his colleagues have been looking at the recovery of marine life in the spot where the asteroid struck. One way of measuring the recovery in an ocean ecosystem, is to look for evidence of primary productivity. Now, primary producers are things at the bottom of the food chain like phytoplankton, and by looking for evidence of their presence, you can get an idea of the state than an ecosystem was in at a particular time. In the asteroid's aftermath, the primary productivity levels in the oceans and seas differed around the world, compared to what they were before the impact.

Interviewee: Chris Lowery
Across the world ocean, there was a big difference in the level of productivity after the Cretaceous. In some places it actually goes up a little bit, particularly in the Pacific, but in a lot of places it drops, and it takes hundreds of thousands of years to get back to Cretaceous levels of productivity. And you see that particularly in the North Atlantic and in the Gulf of Mexico, there is a big drop in productivity that we can see from a lot of different proxies, different biological and chemical aspects of the rocks that we look at tell us that productivity was low for a long time.

Interviewer: Benjamin Thompson
To get an idea of whether the distance from the impact influenced how quickly an ecosystem recovered, Chris and his colleagues went to the source – the crater itself. Now,

the Chicxulub crater is known as a peak ring crater, and it is essentially what its name suggests – a crater with a ring of peaks or hills inside it. Back in 2016, Chris took part in an offshore expedition that drilled some rock core samples from the ring. These cores gave the team a window into the past.

Interviewee: Chris Lowery
So we could see all the way back to the instant that the asteroid hit. So we drilled down, we drilled through 600 metres of postimpact sediment, so we took cores from the lower 200 metres, and we recovered about the first 30 million years after the impact in those cores. And then we got down to the impact rocks themselves, and that, so 66 million years ago, and we were looking at about 120 metres of impact melt and breccia, that was a big jumble of rocks that go back into the crater right after it formed, and then below that we found about 700 metres of pink granite that formed up the peak ring. All of those rocks, all those impact rocks were formed the day the impact hit, and actually the whole cratering process takes about 10 minutes, and so within 10 minutes the peak ring was formed, the melt rock was in place, and most of the breccia was in place as well.

Interviewer: Benjamin Thompson
Shortly after the impact, a layer of fine ocean sediment settled over the rocks in the crater. By looking for fossils within this layer, Chris and his colleagues could estimate how long it took for life to return to this site. It turned out it didn't take long at all.

Interviewee: Chris Lowery
What we found was there was life in the crater, living in the crater, new life within years of the impact, which is surprisingly fast for this life to appear. We found microfossils of planktic foraminifer - these sand-sized zooplankton. We found fossils of calcareous nannoplankton which are primary producers, little algae that form these hard shells. We also found burrows in this settling layer that we know that they were critters, little worms and stuff, living on the seafloor within years.

Interviewer: Benjamin Thompson
Chris suggests that life could have returned to the crater within just two or three years. The team also found evidence that within 30,000 years of the impact, the area had returned to being a high-productivity ecosystem. Now, this is much quicker than the recovery seen in other parts of the Gulf of Mexico, and in the North Atlantic, and it doesn't fit with the hypothesis that ecosystems recovered quicker the further they were from the impact.

Interviewee: Chris Lowery
I would have guessed going in that we would have found slower recovery in the crater, or at least the same recovery as elsewhere in the crater, maybe that wouldn't have proved the hypothesis, maybe that would have left some room open for interpretation, but I definitely would not have expected that the recovery would have been so fast. And I definitely wouldn't have expected that life would have appeared within years in the crater, and so both of those things were surprising in a really exciting, good way.

Interviewer: Benjamin Thompson

It's not yet clear quite how the ecosystem in the area recovered so quickly after it was smashed into by an asteroid that wiped out much of the life on earth. Chris though is hopeful that by learning more about what happened 66 million years ago, we could understand what might happen to ecosystems in the future.

Interviewee: Chris Lowery
What's really exciting about Chicxulub, and Cretaceous mass extinction is, it's really fast. Other mass extinctions in Earth's history were caused by really much slower processes like massive volcanism, these are things that take tens of thousands, hundreds of thousands of years. You know, Chicxulub was a very bad day, and within a couple of years everything that was going to go extinct went extinct, and everything else started to come back and started to reoccupy the oceans and start to diversify after that. And, so that makes it a very interested partial analogue for modern biodiversity loss due to climate change and land use change, and pollution in the oceans and everything else. Chicxulub is probably the only event in Earth history that's faster than what we're currently doing to the oceans and the rest of the planet. And so if we can understand ecosystem dynamics and recovery after that rapid event, it will help us predict ecosystem recovery in the future once these man-made environmental changes kind of subside.

Interviewer: Shamini Bundell
That was Chris Lowery from the University of Texas Institute for Geophysics talking with Benjamin Thompson. You can read Chris' paper over at nature.com/nature.

Interviewer: Adam Levy
Finally this week it's time for the News Chat and acting European Bureau Chief Ewen Callaway joins us in the studio. Hi Ewen.

Interviewee: Ewen Callaway
Howdy.

Interviewer: Adam Levy
First up, we have a story about antibody patents. Now, before we get into what's changed for these patents, can you just give us a little refresher on what an antibody actually is?

Interviewee: Ewen Callaway
Yeah, this is a story from my colleague Heidi Ledford, and antibodies are, they're proteins that our immune system unleashes against infections and other like foreign invaders and they're really special because they have this ability to recognise exquisitely specific parts of these foreign invaders, so a specific protein produced by a virus, or more likely by a virus-infected cell or by a bacterium. So yeah, they're these amazing biological molecules that can recognise most in the other biological substance with amazing specificity.

Interviewer: Adam Levy
And that makes them incredibly useful for medical applications.

Interviewee: Ewen Callaway

Exactly, exactly. And so, people realised that this amazing specificity of antibodies could be used to make drugs, because if you can design an antibody, or you can get an antibody to recognise a molecule that you don't want circulating in somebody's blood to block its activity, you could offer that to somebody as a therapy and it's worked. You know, the first antibody drug I think was approved in the 1980s, they now account for about US$100 billion in drug sales, I mean these are blockbuster drugs.

Interviewer: Adam Levy
But what hasn't been working so well is the way in which these blockbuster drugs are patented. Why has it been difficult to patent antibodies?

Interviewee: Ewen Callaway
Yeah, so antibodies are, these are biological molecules, these are proteins, and so they're quite different from traditional drugs which we call small molecules and you know the exact chemical structure of that small molecule. With antibodies, they're a protein sequence that's encoded by DNA, and the problem is, is that to offer patent protection for an antibody, you need it to have quite broad coverage because you could slightly tweak the specific sequence of an antibody, it would do the exact same thing. So that's no good, you know if you spent all this money making an antibody drug and somebody just changes one letter in your antibody, and you know puts you out of business, that's not good. So the way antibodies were protected was to say this antibody or this set of antibodies that I've produced in my lab recognises this biological protein or this biological target, so I'm going to give you this profile of antibodies that recognise this, which worked for the time being because we didn't actually have a very good way of figuring out exactly where antibodies were binding. You know, I told you that they have this great specificity to bind, you know, any other protein or biological target, but they actually bind specific parts of proteins. And it's a lot of work to figure out which part that is, and only recently has a technology to figure out where antibodies are working, how they're binding, has that become widely available.

Interviewer: Adam Levy
And now we have that level of understanding, how is that changing how antibodies are patented?

Interviewee: Ewen Callaway
Quite a bit actually, it turns out. Recently there was a court case, two very prominent manufacturers of antibody drugs were in a dispute because they both had antibodies targeting the same protein to lower cholesterol. And the court decided that it was no longer sufficient to get an antibody patent to just say you know, I've got this suite of antibodies, it targets this protein. You need to give us a little bit more information, in fact a lot more information about what these antibodies or what this antibody is doing and how it's working to achieve this effect. And so the US Patent and Trademark Office has recently released new guidelines that are setting the bar much, much higher to get a patent for an antibody. They're asking for detailed information about how your antibody or antibodies work before they give you patent protection.

Interviewer: Adam Levy
And this isn't just changing things going forward, it's actually retroactive.

Interviewee: Ewen Callaway
Yeah, it applies retroactively, so, these are very valuable drugs, not only for drug companies, but for the universities whose scientists make the discoveries that often underpin a lot of these antibody drugs. So yeah, I think a lot of people are trying to figure out, you know, which way to go with these new patent rules.

Interviewer: Adam Levy
Now it must be probably quite frustrating for quite a number of biotech companies, but for some it's quite good news.

Interviewee: Ewen Callaway
Yeah, well I guess the patent lawyers are getting a lot more work thrown their way and then these companies that do screening of antibodies, you know, they provide you with information to help you get your patent or just to let you know about how your antibody is working, they're seeing a lot more business as well. So you know, it's glass half full, glass half empty kind of situation. I don't know, science wins, right?

Interviewer: Adam Levy
Well it's always good to know that science wins, and perhaps science is winning in this second story as well, which features a new kind of greener fossil fuel burning power plant. Now before we get to what makes this greener and how it works, how does a conventional power plant work?

Interviewee: Ewen Callaway
Well conventional fossil fuel power plant works by taking a fossil fuel – coal is a popular one, I hear – burning it, and using the energy created by burning that fossil fuel to turn water into steam. The steam then drives a turbine which produced electricity. The downside is that in burning and extracting energy from your fossil fuel, you're releasing carbon dioxide into the atmosphere, and that's a greenhouse warming gas whose levels have been rising precipitously. So the goal I think, the goal really is to put out less CO2 while generating energy.

Interviewer: Adam Levy
And in contrast, how does this power plant work? What's it burning and how is it producing things differently?

Interviewee: Ewen Callaway
So, instead of using steam to drive this turbine to make electricity, it uses heated carbon dioxide. You know, you still get the electricity production, but it makes it much easier to capture the excess carbon dioxide that you're producing from combusting the fossil fuel. And so, you know, a lot of people are really interested in what's called carbon capture and storage, a way to make fossil fuel power plants a little bit greener, and this is a new design for one. So you got a much easier way of capturing that carbon dioxide.

Interviewer: Adam Levy

Is the aim for a power plant like this, that we'd cut down the amount of carbon dioxide being pumped into the atmosphere by a substantial fraction?

Interviewee: Ewen Callaway
I think they're claiming it's a zero emissions power plant. So, at least in the burning of fossil fuels, you know, they're claiming that they're putting no CO2 in the atmosphere. Of course, a lot of other things in the running of a power plant produce CO2, bringing your fossil fuel to the power plant, but yeah they're claiming this is zero emissions so it will be worth following to see if that actually pans out.

Interviewer: Adam Levy
Now I know that that typically carbon capture and storage is somewhat inefficient and expensive, but that's different in this case, right?

Interviewee: Ewen Callaway
As I understand it, a lot of the expense from carbon capture and storage comes to the fact that you have to retrofit an existing power plant to these capacities, whereas this new power plant design is all built from the ground up to capture that carbon dioxide. So its developers who have designed this, they see it as being competitive, price-competitive, with other fossil fuel power plants.

Interviewer: Adam Levy
And what will they actually do with this CO2 once it's captured?

Interviewee: Ewen Callaway
I think they're looking for people to buy it basically, you know, there are a number of chemical manufacturing processes which could use concentrated Co2, so I think they're hoping to find out those markets.

Interviewer: Adam Levy
They're currently testing this plant, what are the next steps?

Interviewee: Ewen Callaway
I think the next steps are to prove that it's as good in reality as they say, as it is on paper. So to put it in the real world and see if it can generate energy at a reasonable pace without pumping as much carbon dioxide into the atmosphere.

Interviewer: Adam Levy
Thank you, Ewen for joining us. For more on all the latest science news, head on over to nature.com/news.

Interviewer: Shamini Bundell
That's all we've got time for this week, but make sure to follow us on Twitter: @NaturePodcast, or for my personal stream of consciousness: @SBundell.

Interviewer: Adam Levy
And you can find me: @ClimateAdam.

Interviewer: Shamini Bundell
And I'm Shamini Bundell. Thanks for listening.

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