Nature Podcast

Introduction

This is a transcript of the 28th June 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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Host: Adam Levy
Welcome back to the *Nature Podcast*. This week, we're hearing how researchers are diagnosing diseased plants from afar, and looking at the link between air pollution and infant mortality in sub-Saharan Africa.

Host: Shamini Bundell
Plus, we'll be learning how newly formed neurons influence how mice respond to stress. I'm Shamini Bundell.

Host: Adam Levy
And I'm Adam Levy.

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Interviewer: Adam Levy
Air pollution causes a vast number of deaths across the globe. But what is that number? Back in 2015, atmospheric scientist Jos Lelieveld told the *Nature Podcast* about his research on the lives air pollution claims.

Interviewee: Jos Lelieveld
This is an astounding number of more than 3 million premature deaths per year worldwide, related to air pollution. It's quite much higher than HIV-AIDS and also, for example, malaria.

Interviewer: Adam Levy
Jos calculated this huge figure by using modelling to capture a global picture of pollution and connect this to pollutants' documented impact on health. But such a global picture can't fully describe important regional details, and this week a study is coming out focusing or air quality in a region that's often been overlooked.

Interviewee: Jen Burney
What struck us was that most of these studies were in middle- or high-income countries.

Interviewer: Adam Levy
This is Jen Burney, one of the authors of this week's paper.

Interviewee: Jen Burney

So, we look at sub-Saharan Africa in this study and that stands out for having very little data really on how much damage air pollution is causing.

Interviewer: Adam Levy
Jen and her colleagues set out to fill in some of the gaps to understand how air pollution affects infant mortality in sub-Saharan Africa. But there's a reason the health effects of air pollution are studied so little in this region – there just isn't as much on-the-ground air quality data as in, say, Western Europe. To get around this the team used remote sensing, teasing apart observations from satellites to estimate the air quality at ground level. They then gathered 65 surveys that capture household health. Carefully combining these two datasets allowed the team to compute the link between the deaths of infants and air pollution.

Interviewee: Jen Burney
Our study here shows that air pollution is actually a much more important cause of excess mortality in sub-Saharan Africa than previously thought. And we find that particular amount of pollution is responsible for more than 20% of infant deaths in our study countries and that exposure to that pollution led to about 400,000 excess infant deaths in that region in 2015 alone. We were surprised to see an effect that was so large and so much larger than existing estimates of mortality. So, this is somewhat sobering in terms of what air pollution really does and what the benefits might be from mitigating it.

Interviewer: Adam Levy
Jen isn't the only one who found these results sobering. I called up Jos who authored the 2015 study to get his thoughts on these new figures.

Interviewee: Jos Lelieveld
It is quite an amazing result that has been represented in this paper and the number of premature deaths in infants is really large. But it is a very serious warning of what needs to be done to protect the health of children.

Interviewer: Adam Levy
This result may be a serious warning, but it's one of many that seek to quantify deaths from poor air quality. How, then, does it fit with Jos' 2015 calculation that around 3 million people die from air pollution globally per year?

Interviewee: Jos Lelieveld
If I now compare this study, we find that the numbers have gone up tremendously, so there is a large number of deaths that we have not yet accounted for properly.

Interviewer: Adam Levy
Jen and her colleagues' study may be accounting for additional deaths because they're not assuming air pollution kills people solely through respiratory infections. Instead, the method simply looks at the relationship between infant deaths and the quality of the air. Their results are substantially larger than the numbers of deaths attributed to respiratory infections.

Interviewee: Jen Burney

And that does suggest that there may be pathways that are not just respiratory. Some of it could also just be that we're only now uncovering these other channels of impact.

Interviewer: Adam Levy
Jos agrees that looking beyond respiratory problems is key to understanding the full impact of air pollution.

Interviewee: Jos Lelieveld
And of course, more research is needed to pinpoint what these other causes are but I think that determining that there is a problem here is already a very important first step.

Interviewer: Adam Levy
But this study doesn't just show how many infants are dying in sub-Saharan Africa as a result of poor air quality. It sketches out the relationship between infant mortality and pollution levels and this shows the impacts that improving air quality could have.

Interviewee: Jos Lelieveld
One of the conclusions is also that, you know, with modest decreases of air pollution, one can achieve at least the improvement in health burden or disease burden in Africa that has been invested for other diseases. Air pollution is something that needs to be put higher up the agenda, because actually with relatively little means one can already do a lot.

Interviewer: Adam Levy
But at present, it's all too easy for policymakers around the world to do little about air pollution. There's a disconnect between the cause and the death. But Jen hopes that studies like hers and Jos' will help make the damage caused by air pollution that much more visible.

Interviewee: Jen Burney
It's one thing to know that poor air quality is bad for health and it's another to be able to say that more than 20% of infant deaths in sub-Saharan Africa in 2015 were due to excess pollution, and to be able to estimate what the benefits would be for a given amount of mitigation. So, we really do hope that by providing this kind of cross-benefit analysis, in some ways, that we can incentivise more action on air quality.

Interviewer: Adam Levy
That was Jen Burney of the University of California, San Diego in the US, and before her Jos Lelieveld who's based at the Max Planck Institute for Chemistry in Germany. To hear our podcast on Jos' study, have a listen to the episode from the 17th September 2015.

Host: Shamini Bundell
Next up, reporter Noah Baker has been investigating a new way to monitor a devastating plant disease.

Interviewer: Noah Baker
Xylella fastidiosa is a plant disease which in recent years has devastated olive crops in Southern Italy. It's also been the focus of significant political controversy – we've covered that in the podcast in the past. Anyway, politics aside, the battle to control *Xylella* infections across Europe has continued. In this month's issue of *Nature Plants* there's a paper

describing a new weapon in the arsenal – a tool to detect infection from the air. Here's Pablo Zarco-Tejada from the Joint Research Centre, part of the European Commission, with more.

Interviewee: Pablo Zarco-Tejada
Xylella fastidiosa is considered one of the most dangerous plant pathogens worldwide.

Interviewer: Noah Baker
The bacterial infection originated in America and was officially identified in Europe in 2013. Part of why it's so feared is because it can infect loads of different plant species, many of which have massive economic value.

Interviewee: Pablo Zarco-Tejada
In America, it's been recorded that it affected citrus and vineyards as well. In the rivalling, in Europe, it's been extremely devastating for the case of olive orchards. In mainland Spain, it's affecting almonds. The problem is that *Xylella fastidiosa* can affect more than 300 different species.

Interviewer: Noah Baker
There's no known cure for *Xylella*. The only approach to combat the disease is to destroy infected trees in the hope of containing its spread. But before that can be done, infected plants must be diagnosed.

Interviewee: Pablo Zarco-Tejada
In the long term we will see defoliation, we will see leaf wilting and we will also detect chlorosis – I mean a reduction of chlorophyll concentration that can be easily detected by our eyes. Plus, as I said, this is in the longer term. In the short term, there are physiological changes that are detectable but we cannot really see darkly with our eyes in the field.

Interviewer: Noah Baker
And it's these pre-visual changes which Pablo wants to detect. You see, once the plant shows visible symptoms, it's already infectious. But if you can catch the infection earlier you stand a better chance of containing it. So, how do you see symptoms which are invisible to the eye? One solution: use more sensitive eyes – namely cameras, in particular, hyperspectral cameras.

Interviewee: Pablo Zarco-Tejada
We scan the surface from manned or unmanned vehicles, I mean even with drones, using hyperspectral sensors. These hyperspectral sensors scan the spectrum from the visible up to the near infrared in what we called narrow spectral bands that are sensitive to specific biochemical constituents. By analysing the hyperspectral data and also thermal data obtained by thermal cameras, we have been able to detect the way some of the plant traits are affected and detect it before our eyes can see it in the field.

Interviewer: Noah Baker
Hyperspectral cameras mounted on drones or planes can detect tiny changes in the levels of pigments in the leaves. This information can be compared with knowledge gained from laboratory studies about how pigments change during *Xylella* infection. Pablo and his team

feed all this hyperspectral data along with other data such as temperature changes into a model.

Interviewee: Pablo Zarco-Tejada
The results of the two-year analysis with evaluating more than 7,000 trees in the field and on our images, is that we can detect if a tree is affected by *Xylella fastidiosa* with accuracies over 80%.

Interviewer: Noah Baker
Now, it's important to note that even more accurate diagnoses can be made by taking samples from trees and testing them in the lab, but that's not necessarily practical. Here's Anne-Katrin Mahlein from the Institute of Sugar Beet Research in Germany.

Interviewee: Anne-Katrin Mahlein
So, the farmer can't be everywhere, so sometimes we have farms which have a quite large size and the farmer is not able to monitor and observe each field on its own, so therefore it would be helpful to have this kind of remote sensing technologies. And also, not every farmer is an expert and one could be much more accurate if we used these kind of non-invasive sensors.

Interviewer: Noah Baker
And it isn't just cameras on flying vehicles. The options for remote sensing are much broader.

Interviewee: Anne-Katrin Mahlein
Yeah, so there are many new developments regarding robotics right now. So, there are autonomous vehicles that can drive over your field and they can be equipped with a camera, the camera can take a picture and you can obtain the information from your robot, for example.

Interviewer: Noah Baker
So, what's next for Pablo's system? Well, his research is produced with the European Commission, but how it's used or implemented is down to the individual EU member states. Here's Pablo.

Interviewee: Pablo Zarco-Tejada
What we are doing here at the JRC is to develop methodologies that will help the member states in order to better monitor and quantify and detect the presence of a disease in their areas.

Interviewer: Noah Baker
There's also a lot of interest in technologies like Pablo's from private companies. Here's Anne-Katrin again.

Interviewee: Anne-Katrin Mahlein
That's a very interesting movement right now, so more and more digital technologies find a way to technical or technological development and different companies invest money and projects in these kind of technologies, and therefore it is expected that it will be available

for the farmer more and more in the near future. But most of the work which is published is basic research and yeah, the next step would be to provide it to the farmer.

Host: Shamini Bundell
That was Anne-Katrin Mahlein from the Institute for Sugar Beet Research in Germany. Before her you heard Pablo Zarco-Tejada from the Joint Research Centre, part of the European Commission. You can read Pablo's paper over at nature.com/nplants.

Host: Adam Levy
Later in the show it's the News Chat, where we'll be discussing plans to harness bacteria to fight disease. Before that, Benjamin Thompson is here with this week's Research Highlights.

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Interviewer: Benjamin Thompson
Researchers in China have created a superhydrophobic material from eggshells, capable of withstanding radiation, corrosive liquids and abrasion. Superhydrophobic materials have a range of uses, for example, creating self-cleaning windows or filtering water from oil. But many existing options are fragile. The team behind this new work may have cracked that problem by collecting eggs from local supermarkets and mixing them first with stearic acid and then with zinc oxide particles. The resulting material showed eggs-traordinary stability, retaining its ability to repel water even after being attacked by sandpaper, strongly acidic or alkaline solutions and UV radiation. The researchers hope that the material will provide new ideas for real-world applications for superhydrophobic technologies. Read this egg-citing research over at *Advanced Engineering Materials*.

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Interviewer: Benjamin Thompson
Oak trees can survive for hundreds of years and are important in many cultures, often used as symbols of strength and endurance. Researchers have now proposed that these trees' longevity may be down to duplications in their DNA. In the new work, a team of researchers sequenced the genome of the pedunculate oak and compared it to the genomes of other plants, including soya and peach. They revealed that between 60 and 80 million years ago, a large number of the oak's genes were duplicated. Many of these genes are involved in disease resistance, which may help the trees reach such old ages. Leaf through that work over at *Nature Plants.*

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Interviewer: Shamini Bundell
Working on the *Nature Podcast* is a pretty fun job, but I must admit I've had a bit of a full-on week. I've got a lot going on, I haven't really been getting enough sleep. So far, I seem to be coping with this admittedly minorly stressful situation and it will certainly pass, but stress and being stressed can have more serious effects. Someone who's interested in the neuroscience behind stress is Christoph Anacker from Columbia University in the US. I gave him a call to find out about his latest research.

Interviewee: Christoph Anacker
So, what we've known from previous clinical studies is that psychological stress is a major risk factor for psychiatric disorders such as anxiety and depression. But we also know that not every individual who experiences stress will ultimately also go on to develop a psychiatric disorder. So, what we wanted to know was what is different in the brain of individuals who are vulnerable to the effects of stress, compared to the brains of individuals who are resilient to stress. Because if we can understand what makes some individuals resilient and while others become susceptible to stress, then perhaps we can find new ways to target these mechanisms of resiliency in order to develop new treatments for psychiatric disorders or even preventative measures.

Interviewer: Shamini Bundell
And in particular, the focus of your study is a region of the brain called the dentate gyrus, and you're studying this in mice, so what does this area do?

Interviewee: Christoph Anacker
So, the dentate gyrus region of the brain is a subregion of the hippocampus. And the hippocampus is a brain region that is mostly known for its role in learning and memory, but it has more recently also been implicated in the regulation of stress responses and emotional behaviour.

Interviewer: Shamini Bundell
And one of the interesting things about the dentate gyrus is that certainly in mice there are new brain cells being made there even in adulthood. So, how much are these new cells involved in the dentate gyrus mediating stress responses?

Interviewee: Christoph Anacker
Yeah, so what we know from previous studies is that, for example, these newborn brain cells in the dentate gyrus can reduce anxiety-like behaviour. But, what we didn't know was how these new brain cells actually influenced the function of the dentate gyrus.

Interviewer: Shamini Bundell
And the formation of new neurons is called neurogenesis, so how did you go about studying the effects of neurogenesis in mice?

Interviewee: Christoph Anacker
So, we used actually mice that have a genetic modification which causes them to produce more of these new brain cells. And what we found was that first of all, mice with more of these new brain cells were also more resilient to stress, and they were less anxious after they experienced chronic stress, compared to the mice with the lower numbers of the adult-born brain cells.

Interviewer: Shamini Bundell
And how did you measure that in mice?

Interviewee: Christoph Anacker
We basically used our experimental mice and we pair them with dominant aggressive mice for 10 days. And for these experimental mice, when they are being exposed to these hostile

social interactions with an aggressive mouse, which is basically like bullying, that is very stressful to these experimental mice and it very robustly causes anxiety and social avoidance.

Interviewer: Shamini Bundell
And you observed the behaviours of these bullied mice and as you said, the mice with more new brain cells seemed less stressed and anxious, but what did that actually change in their brains?

Interviewee: Christoph Anacker
In order to see what effects stress has on the brain, we used a completely new technology which basically allowed us to look inside the brain of the mouse, while the mouse is experiencing stress and anxiety-like behaviour. And to do this we used miniature microscopes that we can attach to the brain of these mice while they are freely moving around. And this technique allowed us to see the activity of individual brain cells in the dentate gyrus region of the hippocampus, while the mouse is experiencing stress and anxiety. And what we found was that stress increases the activity of the dentate gyrus, and in particular stress increases the activity of a subset of cells in the dentate gyrus which seems to be mostly responsive to the effects of stress. And when we then looked in our mice with normal levels of neurogenesis and in our mice with increased levels of neurogenesis, we found that the mice with the higher levels of neurogenesis actually have a dentate gyrus that is much less active in response to stress, and we found that these stress-responsive cells in the dentate gyrus are inhibited by these new brain cells.

Interviewer: Shamini Bundell
And the new neurons inhibiting those cells is what reduces the stress response and long-term stress effects. And are you hoping that understanding this brain area and what's going on there in detail could have direct impacts on how we treat or look at stress conditions in humans?

Interviewee: Christoph Anacker
Yeah, absolutely. I think if we could find ways to, let's say, directly inhibit the dentate gyrus, then we may be able to actually find new strategies to treat psychiatric disorders in better ways, or to even find new ways to prevent them.

Interviewer: Shamini Bundell
But this research is all in mouse brains at the moment, so how similar are the mechanisms likely to be in humans?

Interviewee: Christoph Anacker
In humans it is still a topic of intense debate – how many of these new brain cells actually exist, at what age of development? So, in humans what is clear is that these new brain cells are most abundant until around puberty, so it may be that the effects that we have found in our paper could be particularly strong during early childhood development in humans. In mice, the picture is a little bit different because mice generate a lot more of these new brain cells, and they do so until much later ages than humans do.

Interviewer: Shamini Bundell

So, it's possible that new neurons might not be being created in adult human brains, so if that were the case are the mechanisms in the mice still going to be relevant? The fact that the inhibition of the dentate gyrus cells is what seems linked to stress?

Interviewee: Christoph Anacker
Absolutely, yes. So, it could be that in adulthood when perhaps in humans the number of these adult-born brain cells are very low or perhaps not even there at old ages, then what our mouse studies tell us is that we could basically use this inhibitory mechanism, which may be independent of adult-born neurons, to then also cause these same effects in old age as well.

Interviewer: Shamini Bundell
And you did some experiments with the mice to see if the inhibition of the cells could actually be caused by something other than new neurons?

Interviewee: Christoph Anacker
So, we basically directly inhibited the dentate gyrus and we did that by using a genetically-engineered protein that prohibits the firing of brain cells. And using that technique, we basically found that inhibiting the dentate gyrus directly mimics the effects of increasing neurogenesis. So, when we inhibit the dentate gyrus during the experience of stress, mice were more resilient to the effects of stress and they came out being less anxious in our tests of anxiety-related behaviour.

Interviewer: Shamini Bundell
That was Christoph Anacker of Columbia University. You can find his paper over at nature.com/nature.

Interviewer: Adam Levy
Finally this week, it's time for the News Chat and Physics Reporter Davide Castelvecchi joins us in the studio. Hi Davide.

Interviewee: Davide Castelvecchi
Hello Adam.

Interviewer: Adam Levy
Now, there's been some work which is taking the idea of good bacteria to whole new levels. Can you detail what's going on this report?

Interviewee: Davide Castelvecchi
Yes, so this is a story by our Washington DC-based colleague Sara Reardon, who looked into a number of biotech companies that are looking to engineer bacteria that are similar to those harmless ones commonly found in the body for treating various diseases.

Interviewer: Adam Levy
Now, could you give an example of what the kind of things they're looking to do are?

Interviewee: Davide Castelvecchi

Yes, so for example, there's a genetic disorder where patients lack an enzyme that breaks down an amino acid that is harmful if it builds up in the body in large amounts. So they engineered bacteria to produce this enzyme that breaks down the amino acid, and it's still at the early stages, regulators have approved clinical trials but we still don't know.

Interviewer: Adam Levy
To me that sounds like quite a specific task for bacteria to do, but they're also considering harnessing bacteria to tackle diabetes and HIV infections.

Interviewee: Davide Castelvecchi
Yeah, so for example, another company is looking into bacterium that's often used for making cheese which is also found commonly in the vagina, and it's been shown to help prevent infection by HIV. So, the company is engineering the bacterium to make it more effective at this task.

Interviewer: Adam Levy
Now, this seems like something which could be quite risky – getting bacteria to do this job of protecting the body in one form or another.

Interviewee: Davide Castelvecchi
And in fact, this is a trend that many people are cautious about it because the bacteria are very smart, as one of the sources mentioned. They can evolve to do things that we didn't expect and they can also trade genes among them, among different strains, different types of bacteria. So, if you insert a human gene in a harmless type of bacterium and then it ends up in some other bacteria, then you never know what might happen.

Interviewer: Adam Levy
Is there anything then that researches can do to try and mitigate the risks that using bacteria might involve?

Interviewee: Davide Castelvecchi
Yes, there is various precautions that researchers are taking, for example, engineering the bacteria to make them less able to establish a colony inside the body, or including a sort of kill switch which makes them unable to survive outside of the body so that they cannot be transmitted from one person to another.

Interviewer: Adam Levy
So, with these kinds of solutions does that mean then that this is just a viable approach for medicine and that we're going to be able to use this for treating all sorts of conditions?

Interviewee: Davide Castelvecchi
I think it's too early to know if these techniques are going to work, if they're actually going to be effective at treating the various conditions that they're supposed to treat. And also, it's too early to say if they will be safe – we're at very early stages of these clinical trials.

Interviewer: Adam Levy
From a very tiny story of bacteria to a rather more astronomical story, we are now looking at a mission to an asteroid. What's going on here Davide?

Interviewee: Davide Castelvecchi
The probe called Hayabusa-2 is now literally inching towards its final target, which is an asteroid called Ryugu.

Interviewer: Adam Levy
Is this the first time a probe has approached an asteroid in this way then?

Interviewee: Davide Castelvecchi
No, in fact this is Hayabusa-2 and before it there was Hayabusa-1, which reached an asteroid in 2005. So, these are missions from JAXA – the Japanese Space Agency. There's also been missions by NASA and by the European Space Agency, but this is the first time that a probe is approaching a dark asteroid. They're some of the most common asteroids in the solar system, but they're also some of the most poorly understood.

Interviewer: Adam Levy
So, why is an asteroid like this dark?

Interviewee: Davide Castelvecchi
The common assumption is that it's because it's rich in carbon compounds, but this is the one the things that Hayabusa-2 will have to find out.

Interviewer: Adam Levy
So, what's the probe actually hoping to do when it gets to this dark asteroid?

Interviewee: Davide Castelvecchi
It's a very exciting mission. It's going to do all sorts of things, beginning with mapping the surface with various instruments, and releasing as many as four different landers. These are going to be shoebox-sized things, not very large landers like the ones on Mars. And then the probe itself will approach the asteroid and take samples from it, and then eventually in a couple of years the plan is to return those samples back to Earth where scientists can study them directly.

Interviewer: Adam Levy
So, the probe is actually going to delicately land on the asteroid and then take off again?

Interviewee: Davide Castelvecchi
Yeah, so you have to imagine this is an asteroid that is less than 1 kilometre across. Its gravitational attraction is extremely weak. First of all, the probe will hover over it rather than orbiting, and then it will slowly descend and make a very soft touchdown for just minutes, collect samples, and then lift up again.

Interviewer: Adam Levy
And Hayabusa-2 has actually already started making observations.

Interviewee: Davide Castelvecchi
So, so far, the probe has only begun its approach last week, it got its first pictures from about 300 kilometres away, and then this week it got to within a few tens of kilometres.

And the first thing it measured was how fast the asteroid is spinning, which is good news because it doesn't spin too fast, and it showed a surface with lots of boulders and kind of like boring landscape compared to, for example, the famous rubber duck-shaped comet that we all loved from a couple of years ago. But, it's only the beginning.

Interviewer: Adam Levy
For the team actually involved in this, do they have to work throughout all this to make sure everything goes to plan? Or is it to some extent automated now – out of their hands?

Interviewee: Davide Castelvecchi
No this is actually where the hard work begins. They're going to have to make a lot of decisions, important decisions, beginning with identifying the best landing spots for the landers where, for example, you know, they don't hit a boulder or they don't get stuck in a crevasse.

Interviewer: Adam Levy
Thank you, Davide. Listeners, don't forget you can find all the latest science news over at nature.com/news.

Host: Shamini Bundell
That's it for this week's show, but don't forget you can get in contact with us on email – we're podcast@nature.com, or on Twitter where we're @NaturePodcast. If you're a fan of the show and you'd like to leave us some stars or a review, then that does help us get the show out to even more people. I'm Shamini Bundell.

Host: Adam Levy
And I'm Adam Levy. Thanks for listening.

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