Science Magazine Podcast
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Music

Host – Sarah Crespi
Welcome to the *Science* Podcast for November 8th, 2013. I'm Sarah Crespi.

Host – Linda Poon
And I'm Linda Poon. This week on the show we have stories on chasing a meteorite to ground [00:49], climate adaptation science [11:20], and the forgotten malaria [21:26]...

Interviewee – Gretchen Vogel
Tens of thousands of syphilis patients were treated with malaria. Not all of them got better. Some of them died. But many of them did recover.

Host – Sarah Crespi
Plus, a few stories from our online daily news site [29:29].

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[00:49]
Host – Linda Poon
The asteroid that tore through Earth's atmosphere and plummeted toward Chelyabinsk, Russia, earlier this year created the largest airburst of its kind since 1908. And since the meteorite crash-landed in a region with dash cams and cutting-edge lab techniques, researchers have gained an unprecedented ability to study the impact. Peter Jenniskens discusses the findings with Kristy Hamilton.

Interviewee - Peter Jenniskens
On February 15, 2013, a small asteroid entered earth's atmosphere at a high speed of 19 km/sec. And it came in on a relatively shallow angle, penetrated deep but held together but then around 30 km altitude it catastrophically fragmented. We visited about 50 villages in the area in the weeks following this event as part of the Russian Academy of Sciences field study, and we found that the wave created damage as far as 90 km away from the asteroid trajectory.

Interviewer - Kristy Hamilton
So much of the airborne data was gathered from dash cams and security camera

videos of the fireball, so what kind of information were you able to glean about the meteor as it was plummeting to earth?

Interviewee - Peter Jenniskens
Well, we were very lucky that this event was so well observed. This happened in a highly populated area, so we have hundreds of videos that documented the fireball entry and also the effects of the shock wave on the ground. And so we were able to use that video after going through a number of locations where video was taken and very carefully measuring the star background to the reactions in which things were seen, to calculate the approach trajectory, how fast did it come in and what sort of angle did it come in, how did it brighten during its entry, what were the phenomenon that occurred during its entry?

Interviewer - Kristy Hamilton
So it was reported that the light of the meteor was brighter than the sun and bright enough to cast moving shadows during the morning. What temperature estimates were drawn and how did you go about calculating it?

Interviewee - Peter Jenniskens
Well, when the object fragmented at 30 km it became so bright that it was brighter than the sun. And it was in fact so bright in the ultraviolet that some eye-witnesses reported being sunburned by the light. An interesting aspect here was how much of the energy of entry—the kinetic energy, the energy of movement—was released at that time. And it was a lot of it. This object fragmented very efficiently at that point. It was really an exponential increase of fragmentation. And it's at that time that all the fragments were created that were later found as meteorites on the ground.

Interviewer - Kristy Hamilton
And is this also why we can see two dust trains billowing in pictures of the meteor?

Interviewee - Peter Jenniskens
Interestingly enough, yes and no. In most pictures of the meteor you see these two bands of smoke that are along the path of the fireball, but that is caused by the buoyancy of the hot air. So the air rises and then cylindrical vortices are created which split the train in two. If you look carefully, you can see that after the really big fragmentation event there are two big fragments emerging. Each fragment has in its wake a cloud of dust and that cloud you can also see splits in two. But one of the two fragments then subsequently breaks into pieces and disappears. But the other one continues to sail on, and we now know it ultimately ended up hitting the ice of Lake Chebarkul where it created a big hole and was later recovered from the lakebed.

Interviewer - Kristy Hamilton
And so what do we know about that impact? How big was the meteorite found?

Interviewee - Peter Jenniskens
Oh, I'm very excited about the fact that just before we went to press, a video emerged that actually shows the impact of the main fragment. This video was taken by a video security camera on the shores of Lake Chebarkul. It shows the moment that the rock hits the ice. You see in the far distance a cloud of ice or snow lift up in the air and then the winds blow that cloud away out of the frame of the video camera. So what that video did for us was it measured very precisely the timing: how long did it take the big piece to land on the ice from being up in the atmosphere? And from that we were able to calculate how hard the rock hit the ice and we found that it was about 225 m/sec.

Interviewer - Kristy Hamilton
Oh wow. And how much did it weigh?

Interviewee - Peter Jenniskens
I…well, the scale broke when people tried to get an accurate result and at the time of press we do not yet know the exact weight. But the weight estimates that people made in Russia, the weight was estimated between 600 and 650 kilos.

Interviewer - Kristy Hamilton
And something that I was really interested in was the shock and melt veins. What can that reveal about a meteorite and about this one in particular?

Interviewee - Peter Jenniskens
Yes, we were looking for something about this asteroid that made it so frail, and why it so efficiently fragmented at about 30 km altitude. And when the shock veins were closely examined with an electron microscope, these shock veins showed some peculiar features, one of which was that it had, along the side of the veins, it had a layer of tiny iron crystals. We think that those iron grains settled out of the melt when this melt cooled, and we suspect that that could have led to some weakness in the shock veins. When we put the press on one of the meteorites, we found that it actually broke along one of these shock veins.

Interviewer - Kristy Hamilton
So can researchers discern whether the veins were created by an impact event in space or with earth?

Interviewee - Peter Jenniskens
The veins were created by an impact event in space. We did find that this particular chunk of rock that was Chelyabinsk meteorite was hit pretty badly about 150 million years after formation of the solar system—so relatively late after the parent body of this type of meteorite was formed. And we know it was hit pretty hard because if you look at the rock and see that the metal grains that are in the rock have been oriented and flattened just by the pressure wave going through the rock.

Interviewer - Kristy Hamilton
What are the rest of the compositional findings of the Chelyabinsk meteorite? What else did you find?

Interviewee - Peter Jenniskens
In general it seems to be part of the LL chondrite group of meteorites and that LL chondrite group we think originated from a group of asteroids in the asteroid belt called the Flora family. It's a really interesting type because it's the same as that of Asteroid Itokawa for which the Hayabusa Mission brought back some material, and that too was linked back to the Flora family. So what Chelyabinsk did for us was it added an orbit and it is the very first orbit that we have of such an LL chondrite object. It gives us now a higher confidence that indeed these meteorites are originating from the inner part of the asteroid belt.

Interviewer - Kristy Hamilton
Usually we can tell if there's going to be a near-earth asteroid collision, and this one is pretty large. So how come we missed this one?

Interviewee - Peter Jenniskens
We missed this one because its approach was from the daytime side. So you can imagine that if a rock goes around the sun and it moves in a bit of a centric orbit, it can come in from the nighttime side. Then it rounds the sun and it comes back on the daytime side. And so typically we have as much things coming in on the nighttime side as we have things coming in on the daytime side. And sadly, you know, the sun is in the way.

Interviewer - Kristy Hamilton
This impact is one in a string of similar recent events. So how do these findings compare to the other meteorites such as the one at Sutter's Mill?

Interviewee - Peter Jenniskens
This one compares to the meteorite found at Sutter's Mill by being about 100 times bigger and more energetic, which is incredible. The one in Sutter's Mill created a loud boom that shook houses, and it was this shock wave that really caused glass damage in Chelyabinsk. In that area, not just the windows were pushed in but also the whole window frame was pushed into the buildings. That wave was so strong that it was able to topple over people standing.

Interviewer - Kristy Hamilton
The researchers also measured the thermoluminescence, correct?

Interviewee - Peter Jenniskens
Yes.

Interviewer - Kristy Hamilton
What is the thermoluminescence and what did we learn from these experiments?

Interviewee - Peter Jenniskens
Thermoluminescence is one of the techniques we use to probe the meteorite. And

what it tells us is we can get a sense on when was the last time that this material was heated? And interestingly enough, the signals in this rock were very low. We suspect that was because the feldspar material was destroyed in past shock events. Otherwise we can say that, yes, these signals were consistent with this object having moved sort of as close to the sun as we can see from the current orbit of the meteorite. So that suggests that the object was not closer to the sun in the past. It sort of gradually evolved into this orbit. And that matches with another peculiar aspect of this find, and that is that this rock was in space as such—as a rock like this—only for about 1.2 million years, which is a relatively short period of time as far as the evolution of asteroids and near-earth objects go. So we are thinking that this rock probably did not break in the asteroid belt itself as part of the ongoing cascade of collisions that is the asteroid family called Flora. So we think this thing broke on its way in, when it was already in an orbit coming close to the planets. And there are several ways in which these rocks can break but one of the ways is by tidal forces if the rock originally was a rubble pile of debris. In that case, when you have a close encounter with a planet, you can tear this pile apart, and from that moment on Chelyabinsk can go on its way as a separate rock. And speculating that perhaps 1.2 million years ago we already had a close encounter with the Chelyabinsk meteoroid at which time the rock split in two and this object went on its course, only to hit us now very recently.

Interviewer - Kristy Hamilton
Well, Peter Jenniskens, thanks for talking with me.

Interviewee - Peter Jenniskens
Pleasure.

Host – Linda Poon
Peter Jenniskens and colleagues write about the Chelyabinsk meteor in a Science Express report this week. You can read it at www.scienceexpress.org.

Music

[11:20]
Host – Sarah Crespi
Climate change is not in question. But what we do need to ask at this point is: how do we prepare for the effects of climate change in an organized manner? I spoke with Richard Moss about a Policy Forum in this week's issue outlining the future of "adaptation science."

Interviewee - Richard Moss
Our article really starts from the observation that climate variability and extreme events are already causing major damages in society—witness Hurricane Sandy just last year—and due to human influences these climate extremes are expected to become more variable and more intense. There's quite a bit of evidence of that. As a result, most sectors and natural ecosystems around the world are actually going to have to adapt or prepare in some way. And what we're talking about here in this article, "Adaptation Science," it's about finding a way to both continue to add to our basic knowledge about

climate and its effects and then also enabling people to use this knowledge in applications in ways appropriate to its level of certainty.

Interviewer - Sarah Crespi
And so why is this important to talk about now?

Interviewee - Richard Moss
Well, this is particularly important to talk about now because of…I don't know if you picked up just last week, President Obama issued an Executive Order focused on adaptation and adaptation science. What he does in that Executive Order, actually, is establish—among other things—some mechanisms that are intended to make it easier for states and communities to prepare for climate change. And it establishes some coordination mechanisms that would enable them to have access and influence in decisions, for example, about long-lived infrastructure such as roads or pipelines or whatnot. And so where is the information going to come from to do that? That's one of the things that adaptation science is really intended to provide. The second reason why it's really important just has to do with the mechanisms through which our country organizes and conducts climate change research. There is a federal program called the U.S. Global Change Research Program, which is actually quite important and large—it's a consortium of 13 agencies—and they just completed a strategic planning process. In that process, they identified adaptation and supporting adaptation decision-making as one of their key challenges. And while they identified the challenge, they're really not able in the strategic plan to go into as much detail about how adaptation science should be organized and how it can be advanced. And so we just felt that this would be a timely addition to the literature that focused on that latter program.

Interviewer - Sarah Crespi
We do know some about the upcoming effects of climate change, but there are gaps in our knowledge. Can you talk about some of that missing information?

Interviewee - Richard Moss
Sure. But I do think I just want to emphasize the point that you started with, which is that there is actually quite a bit already known about how climate is changing, both in the near and longer term, as well as vulnerability in processes through which changes in climate actually affect the things that are more directly relevant for societal well-being, like agriculture and water resources. In the article, we do point out that there are a number of information gaps related to approaches for doing vulnerability assessment, you know, issues related to understanding recent and potential future changes and extreme climate events. And you know trying to really tailor the climate information that's available to the particular applications—that's another key challenge. And then finally getting information actually pulled together about social and environmental phenomena and putting that into a common format so we can do better analysis is really crucial, as is coming up with evaluation methods for the information and the measures that are taken.

Interviewer - Sarah Crespi
Can you give an example of that?

Interviewee - Richard Moss
Yeah, okay. So an example of, in particular, the evaluation measures, you might look at a couple of years before Hurricane Sandy even hit, New York City had been thinking about climate change and it established an adaptation task force that involved both climate scientists and officials involved in managing New York City. And these were both public officials as well as individuals from private companies—for example, some of the utilities. And they put in place some adaptation measures before Hurricane Sandy hit, but nobody's really thought about evaluating whether those measures were adequate or not. You know, we don't know, for example, how much damage might have been avoided that would have occurred in addition to what was experienced in New York, if those measures hadn't been taken. That's kind of an example of what I mean by trying to put in place the research to better understand whether this is actually being effective.

Interviewer - Sarah Crespi
One of the goals of this approach is to supply evidence-based options to decision makers. How do you see that playing out? You gave the example of Sandy, but you're kind of talking about making this…expanding this effort to get the information to the right people.

Interviewee - Richard Moss
Right. You know, it's kind of interesting to see how this is already playing out in a couple of experimental programs that some of the federal agencies have put together. One in particular that I'll mention is the Regional Integrated Sciences and Assessment Program, which is part of NOAA, the organization that—among other thing—runs the Weather Service. And basically what it is is an experimental approach to put together university-based researchers in sort of interdisciplinary way—so it's drawing on social and natural science—and enabling them to work with natural resource managers and other planners within their own region. And some of the interesting things about this are the fact that it seems to be the case that the local scientists actually have a great deal more credibility with the end-users and they actually also have a better understanding of what the decision applications might be. So it enables them to come to a better understanding of exactly what research is required to do a better job with decision-making and management. You know, and there's also some interesting things that arise related to, you know, what are the incentives for university-based researchers who primarily survive on their ability to publish in distinguished journals like *Science*? What are the incentives for them to engage in these sort of more applied activities? You know, so there's been interesting learning all the way around. It's been going now for close to a decade but still I would say early days of trying to figure out how best to do this.

Interviewer - Sarah Crespi
Just going back to your point about the incentives for, you know, university-based researchers. What about the incentives for governments and institutions that have control over these decisions? I mean, just having the information isn't always enough to get them to make the right decisions. Does this have any effect on that?

Interviewee - Richard Moss
Oh, sure. I mean, that's a huge issue because, you know, you can provide people with information but it doesn't necessarily make it easy for them to use. We actually talk in

the article about when we say understanding decision processes and knowledge requirements, it really involves actually understanding some of the other things like cost or social acceptance or tradition or interests of pressure groups that actually affect decision-making. So to make the science that we're talking about here usable in those other contexts, it's really important to understand kind of all the influences on decision-making and to find the best entry points for application of scientific information.

Interviewer - Sarah Crespi
So the purpose of this paper—what's the takeaway? Are you trying to influence governments?

Interviewee - Richard Moss
The article isn't primarily about government implementation. What we're really trying to do in this article is synthesize across a whole range of fields. And you can see how broad a range of fields that is simply by looking at the authorship list. There's more than two dozen authors on this article and they come from natural science, social science, physical climate modeling—all manner of disciplines, and even some folks who have had some experience, for example, in resources management. We did have some users involved as well. That's really what our focus was. You know, we did suggest towards the end of the article that there were some things we thought that could be tried to try to advance this area of science. One idea was just to try to see an increased emphasis on decision sciences and social sciences and programs like the USGCRP. Another was to sort of suggest that maybe some of the basic science programs could start to be a little bit more strategic in at least some of their research. And I think that some already have, for example at the National Science Foundation. Something that's being tried in the United Kingdom that's quite interesting is they want to see an end-user included in the proposal. And then finally one that we suggest that we think that really does bear some examination but also a lot more explanation is, you know, we looked at the National Institutes of Health as an example of an agency that's both basic research as well as very focused on practical problems, in this case sort of clinical health issues. And what we saw was is that this model actually evolved over time. It didn't exist in its current form right away at the beginning but as new problems were identified and opportunities for scientific progress seemed to exist, we noticed that new institutes were added. And this seemed like actually a fairly interesting base model for something like a National Institute of Preparedness where you could again see evolution over time, building on existing efforts, but really bringing together both basic science and those who would need to apply it into a more integrated setting. And so it wouldn't be actually a physical institute as much as it would be a virtual one.

Interviewer - Sarah Crespi
Very interesting. Richard Moss, thanks so much for talking with me.

Interviewee - Richard Moss
Thanks very much for having me. It's a real privilege to be on the program.

Host – Sarah Crespi
Richard Moss and colleagues write about the future of adaption science in a Policy Forum this week.

Music

[21:26]
Host – Linda Poon
Despite wreaking havoc on the body through recurring fever, chills, and muscle pain, history once hailed the vivax parasite as a miracle cure for syphilis. But the thinking on the "other malaria" is beginning to change. As Gretchen Vogel reports, scientists are now bringing the disease back into the spotlight as part of their mission to eradicate malaria globally.

Interviewee - Gretchen Vogel
Plasmodium vivax is one of several parasites that can cause malaria in humans, and it's not as well known as its cousin, *Plasmodium falciparum*. *Plasmodium falciparum* does cause most of the malaria cases across the world and causes a vast majority of deaths across the world. It tends to be more lethal. But researchers have recognized in recent years that vivax malaria, which was once officially called benign, is actually not benign at all and causes a lot of severe disease across the world. It's pretty rare in sub-Saharan Africa, in part because populations there carry a genetic trait that leaves them partially resistant to *Plasmodium vivax*. But it is widespread across Asia, Central America and South America, and there it causes a great amount of suffering. And recent estimates have estimated that roughly a third of the world's population is thought to be at risk for vivax infection.

Interviewer - Linda Poon
So the vivax parasite actually has a pretty interesting history. At one point it was considered a life-saver. What was the thinking behind that?

Interviewee - Gretchen Vogel
It's an unusual and fascinating chapter in medical history. In the late 1800s before antibiotics were available there was a theory that inducing really high fevers in patients could perhaps cure some mental illnesses, a whole variety of them. And an Austrian psychiatrist, Julius Wagner-Juaregg, was one of the proponents of this idea. And in the 1880s and 1890s he tested some of his theories, but it didn't work. But he didn't give up, and in 1917 he had another chance. He had a patient who had come back from the Balkans and was infected with malaria, and he took some blood from this patient and injected it into nine patients who had end-stage syphilis. At the time, syphilis was a death sentence and by the time you reached end-stage you were neurotic and were gradually becoming paralyzed. It turns out that six of these nine patients got better, and Wagner-Juaregg was actually awarded the Nobel Prize in 1927 for this discovery, and his methods spread across Europe and the United States. And tens of thousands of syphilis patients were treated with malaria. Not all of them got better; some of them died. But many of them did recover, at least partially, and it was considered for a while a miracle cure.

Interviewer - Linda Poon
All right. So it kind of fell out of the spotlight once antibiotics came into the picture. But if more than a third of the world's population is at risk of vivax malaria, why for so long has it not gotten much negative spotlight?

Interviewee - Gretchen Vogel
Well, in part some researchers actually blame this malaria therapy for its benign reputation. It isn't as deadly as falciparum malaria, but it does cause some pretty severe disease and is often a cofactor in people's deaths. And so for a long time, because falciparum malaria is so deadly and so widespread, people sort of thought, ah, we don't really need to pay much attention to vivax. But in recent years there's been a global campaign against malaria that has had some significant successes. And actually the tools that we have to fight malaria are more effective against falciparum malaria. Vivax malaria has some tricks up its sleeve that makes it harder to fight. And so as overall rates of malaria fall, the proportion of cases that are left—that are caused by vivax—go up. And so that has sort of reawakened interest in this sometimes forgotten parasite and made people realize, wait a minute, if we're going to tackle the malaria problem we need to tackle vivax as well.

Interviewer - Linda Poon
Researchers are still working to eradicate falciparum malaria. In what ways will the vivax be a tougher challenge?

Interviewee - Gretchen Vogel
The main reason it's a tougher challenge is that it can hide out in the liver where it's undetectable. You can't just give somebody a blood test and tell whether they have these hiding liver parasites. And it doesn't cause any detectable symptoms either. But then it can come out of dormancy and wake up and cause malaria again and pass on to the next mosquitos which then will pass on to the next human hosts. And so this characteristic of the parasite makes it really hard on a large scale to get rid of in a region, because it can hide out in all these asymptomatic patients. There is one drug that's currently available that can kill—the stage is called the hypnozoite stage of the malaria life cycle—and it means sort of 'sleeping parasite.' But it has a drawback in that it can cause potentially deadly side effects in people who carry a certain kind of genetic trait that leaves them deficient in a certain enzyme. And this trait is, of course—as luck would have it—fairly common in regions where vivax malaria is also common. Currently the dose required is a 14-day dose of drugs, and if you're trying to treat people who don't feel sick at all because they have these dormant or sleeping parasites, to get them to take consistently 14 days' worth of drugs is a challenge.

Interviewer - Linda Poon
So given that challenge, what other efforts are underway and how optimistic are researchers about finally eradicating malaria?

Interviewee - Gretchen Vogel
There are a few bright spots. The new attention to vivax malaria has made people more aware of the problem and is helping also to just bring light to the fact that a lot of cases of vivax malaria had been hidden. The diagnostic tests for malaria don't always distinguish between the different species of parasites, and so the fact that people are paying more attention is also helping people to better understand how widespread the problem is. There's also some good news on the drug front potentially. There are some new clinical data coming out on a potential new drug called tafenoquine that look pretty promising; they'll be announced next week at a meeting and people are optimistic that that might be

a really helpful tool in fighting vivax. The key there is that this new drug would require only a single dose instead of the two-week course, so you could give people just one dose of the drug and it would apparently kill all of the sleeping parasites, all the dormant-stage parasites in the liver.

Interviewer - Linda Poon
So in your story you quoted a researcher who said that the final battle against malaria is the battle against vivax. Is it more important to tackle vivax rather than falciparum?

Interviewee - Gretchen Vogel
No, it's much more important still to focus on falciparum now. Most of the people who die of malaria are children in Africa, and it's almost always falciparum that kills them. So that is a key, key battle that has to be fought and most of the energy probably still belongs there. But as those efforts have some success, vivax tends to still hang on and remain. And so the final battle—if you're really trying to eliminate malaria from a region, you can't ignore vivax because you're going to have to deal with that at some point and get rid of it as well.

Interviewer - Linda Poon
All right. Well, Gretchen Vogel, thank you so much for talking with me.

Interviewee - Gretchen Vogel
Thanks very much.

Host – Linda Poon
Gretchen Vogel writes about the battle against the forgotten malaria in this week's *Science*.

Music

Host – Sarah Crespi
This week in *Science*. On the site this week you can read a Review on the similarities between embryonic cells and cancer cells. Also in the research section, there's a Report on the cause of the asymmetrical distribution of impact craters on the moon's surface. And in a News and Analysis story this week, we learn about scientist-soldiers in Afghanistan. You can check out all these stories and more at sciencemag.org.

Music

[29:29]
Interviewer - Sarah Crespi
Finally today, David Grimm, editor for our daily news site, *Science*NOW, is here to talk about some recent stories. I'm Sarah Crespi. So first up, Dave, we have a story on the social fabric of elephant herds. For anyone who's seen the Disney movie *Dumbo*, it may come as no surprise that elephants feel sad sometimes but has yet to be scientifically quantified.

Interviewee - David Grimm
Well Sarah, you know, it is a good question, you know, what emotions other animals feel. This study isn't so much about whether elephants feel sad but more about what sort of impact traumatic events have on elephants that witness these events early in their lives.

Interviewer - Sarah Crespi
So this is actually about a practice called culling. What is culling and why would we do it?

Interviewee - David Grimm
Well, culling has been used in South Africa from about the 1960s to the 1990s, and basically what it is is a tool to thin elephant herds. And the reason you'd want to do that is because when there's too many elephants on a piece of land they can be very destructive to the habitat, especially if they're in a fenced reserve. And so what wildlife managers would do is they would get in a helicopter which would herd an elephant family into a tight bunch, and then hunters would shoot as many of the animals as possible as quickly as possible, leaving only the young elephants—elephants from about four to 10 years of age—alive, and then these young elephants would be shipped to other parks that didn't have as many elephants. And researchers have known for a while that this isn't good for the young elephants. They seem to suffer from posttraumatic stress disorder. Elephants that have grown up with such trauma tend to be a lot more aggressive, they kill rhinoceroses, they attack tourist vehicles. But nobody's really looked at how this sort of impacts more fundamental aspects of these animals' lives. Social learning is really important for elephants and the question has been, does this early life trauma impact their social learning?

Interviewer - Sarah Crespi
Right. So how did they end up looking at this in more detail?

Interviewee - David Grimm
Well, Sarah, they compared two populations of elephants. One was from Kenya's Amboseli National Park, and the elephants here really haven't been through a whole lot of trauma in their lives. And they compared them to elephants that grew up on the Pilanesberg Reserve, and these elephants…a lot of them were exposed to this early culling trauma. And then what they did was they played a few calls from other elephants and they manipulated these calls so they would sound like they came from a dominant, strange female. And strange means a female that neither group knew. And usually when elephants hear this call, they get really cautious because calls from these dominant stranger females can indicate that maybe a female is approaching that can pose a danger to the family. And here's what one of those calls sounds like. *<elephant call>* And when they played this call for the Amboseli elephants—the elephants that really hadn't been exposed to trauma early in their lives—the elephants acted appropriately. They froze, they bunched together, and sometimes they even charge towards where the sound was coming from maybe in an attempt to scare off this intruding female. But the Pilanesberg elephants, the ones that had been exposed to trauma early in

life, didn't react appropriately at all. In fact, their reactions were really random. Sometimes they left the area, sometimes they didn't do anything at all, they just sort of sat there relaxed. And this indicates that these elephants really aren't sharing this social knowledge that's so important for not only their survival but really understanding how to react to other elephants in their midst.

Interviewer - Sarah Crespi
Why do they think that this is due to the culling trauma?

Interviewee - David Grimm
Well, when these young elephants are relocated to new reserves, they form family units again. So that indicates that it's not the fact that they haven't interacted with adults in their lives, it's that maybe they're not able to learn for some reason from these interactions. There's something that's become very messed up about them that they're just not able to engage socially or learn socially like they usually do.

Interviewer - Sarah Crespi
And so what does it mean when an elephant doesn't know how to behave socially? What are the consequences?

Interviewee - David Grimm
Well, one of the big consequences is it can actually interfere with their reproductive success. You can imagine if you don't really understand the signals of another elephant, you're not going to be able to mate with that elephant and you're not going to be able to sire offspring. So even though these young elephants were spared early in their lives from culling, they may actually have a very bleak future.

Interviewer - Sarah Crespi
Next up we have a story on newborn infections. Babies are particularly prone to cold, flu, infections in general. But the question is, why are their immune systems so weak at that time in their lives?

Interviewee - David Grimm
Right. It's been a really big question and obviously it's a very important question, because actually newborns are much more likely to die than older babies of these types of infections. And, for some reason, having a weak immune system at birth must serve some sort of important function. And scientists have had a few hypotheses. They've thought, well maybe just like everything else, when a newborn is born, you know, not everything is fully developed yet and the immune system might just be one of those things. You know, it's just not as developed as it will be later on. The other idea has been that because the baby spends so much time in the mother's uterus that it must suppress its immune system otherwise it will reject the mother and also the mother may do the same thing—she suppresses her immune system so she doesn't reject the baby. But this new study actually has a different conclusion.

Interviewer - Sarah Crespi
So what's the third option?

Interviewee - David Grimm
Well, the third option— according to this new research— is that infants may actually suppress their immune system because they are trying to build up this, what scientists call microbiome in their guts. And this is the population of bacteria that's been shown to be really important for everything from our weight to our metabolism to even things like arthritis and potentially even behavior.

Interviewer - Sarah Crespi
So how did they figure out that the third option might be the right one?

Interviewee - David Grimm
They did all these experiments in mice. And the first thing they did was they gave strong immune cells—they injected them into newborn mice. And they found that these immune cells just kind of turned off in the newborn mice. But when they did the opposite and they took the newborn mice's immune cells and placed them into adults, those cells which had been dormant turned on. So they figured there must be something going on in the body of the newborns that's shutting their immune system down or at least really muting it. When they looked a little bit closer, they found that there was this particular class of immune cells that eventually develop into red blood cells. They express a surface receptor called CD71, which causes the immune suppression of other cells. When they knocked out these cells, they found that young mice started to get a lot of inflammation in their intestines. But as the mice grew older, there were fewer and fewer cells that had these CD71 receptors, suggesting that the mice were somehow over time ramping up their immune system or activating their immune system, but that very early on they were deactivating it. And the researchers take all this together and they basically think what's happening is that this is something that's done on purpose as the mice are developing this gut microbiome, they don't want to be killing off all the bacteria that are growing in their guts which is what the immune system would do. And so they have to keep their immune systems suppressed early on, and they only ramp it up later once that microbiome has fully established itself.

Interviewer - Sarah Crespi
So this is a really interesting finding for how we get that gut microbiome that seems to stick with us for quite a long time. Are there any other implications for this finding?

Interviewee - David Grimm
Well, the researchers are hoping that this could provide a way to make sure that newborns, even though they have reduced immune systems, are still protected from infection. And one idea was actually giving them immune cells that they wouldn't be able to turn off that would protect them early on in life and that maybe these cells would disappear once the baby's immune system became a lot stronger.

Interviewer - Sarah Crespi
Finally we have a story on virtual arms. Last year, a paralyzed person was able to move a mechanical arm with just her mind. Now a research group is trying to top that by controlling two arms with a brain-machine interface. So Dave, why are two arms so much better than one?

Interviewee - David Grimm
Well, try to hug a person with one arm, try to shop at the grocery store, pull items off the shelf with one arm. It's actually a lot more complicated than it seems. And it's been an incredibly tricky problem for researchers developing so-called brain–machine interfaces or BMIs. These are ways for paralyzed people to still be able to pick stuff up when either they don't have limbs or they don't have the use of their limbs. But using both arms is not as simple as, okay, we figured out how to get a person to use one arm, then we just add another arm to the equation because, as you can imagine, there is a complex interplay when we move both arms. Each arm has to sort of know what the other arm is doing; they have to act in concert and that's really incredibly complicated at a neurological level. And that's why this new study is such an advance, because what the researchers were able to do is they were able to take monkeys and train them how to use two virtual arms on a computer.

Interviewer - Sarah Crespi
Well, let's step back for a second. How exactly does a brain–machine interface work?

Interviewee - David Grimm
Well, usually when you can't—especially if you're paralyzed and you can't move your arm—for some reason the signals from your brain are no longer getting to your arm. And so what these BMIs do is they basically take the signals from your brain directly and then they translate those signals into the movement of either a robotic arm or, in this case, a virtual arm.

Interviewer - Sarah Crespi
So for the monkeys, what were they moving with their minds?

Interviewee - David Grimm
They actually looked at two monkeys and they implanted electrodes into both the left and the right side of their brains to pick up on these signals that tell limbs to move. And what the monkeys were trying to do was they had to control two virtual arms—you can actually see a picture of this, actually a video as well, on the site—and their goal was to place both hands over two virtual circles and hold them there for 100 milliseconds. Now that may not sound hard, but when you're trying to move virtual objects with your mind, it's pretty tricky. But the researchers found that over time, the monkeys were able to do this. They first train them how to do this using joysticks, actual joysticks. Then they took the joysticks away, they strapped the monkeys down so they couldn't use their arms—their real arms—anymore, and then they wanted to see could the monkeys learn

how to use these virtual arms. And in most cases, over time, they were able to do that.

Interviewer - Sarah Crespi
So this would actually work for a person who couldn't practice with a joystick or a keyboard, they'd just be able to watch what happened and then learn to use their mind to do the same thing?

Interviewee - David Grimm
Right. Well, one of the monkeys, she was trained first with the joysticks. But the other monkey had to do without that training because they wanted to find something that would be analogous to a person that didn't have the use of their limbs from the very beginning. You know, this monkey took longer and wasn't as successful, but eventually he was also able to control these virtual arms.

Interviewer - Sarah Crespi
So this study not only demonstrates something amazing that we can now do with brain–machine interfaces but it also was able to tell us something new about how the brain works. Can you talk about that?

Interviewee - David Grimm
Well, yeah, as you say Sarah, it's not just a cool advance. It's actually teaching us a lot more about how the mind works. And it turns out that by measuring all of these signals in the brain, the researchers are also figuring out how exactly the brain coordinates the movement, even in people that aren't paralyzed in the first place. And that could really shed some light into how the brain works.

Interviewer - Sarah Crespi
So what are the next steps for this research? We've got two arms. What's next?

Interviewee - David Grimm
Well, two legs, of course. In fact, the scientist who led this research is hoping - and indeed promised on the *Daily Show* - that by the 2014 Brazil World Cup he will have created a robotic body suit that will enable a paralyzed person to kick a soccer ball. And that's only a year away.

Interviewer - Sarah Crespi
Okay. So what else is on the site this week, Dave?

Interviewee - David Grimm
Well, Sarah, for *Science*NOW we've got a story about a giant ancient platypus, the first ever evidence of insect sex, and also—speaking of the microbiome—how the bacteria in our guts may cause arthritis. For *Science*Insider, our policy blog, we've got a story about how science is faring in the United States Senate. Also a story about why a U.S. court invalidated a patent for a Down syndrome test. Finally for *Science*LIVE, our weekly chat on the hottest talks in science, this week's *Science*LIVE is about unraveling the mysteries of dark matter. And next week's *Science*LIVE is—speaking of neuroprosthetics—all about neuroprosthetics. So be sure to check out all of these stories on the site.

Interviewer - Sarah Crespi
Thanks Dave.

Interviewee - David Grimm
Thanks Sarah.

Interviewer - Sarah Crespi
David Grimm is the editor for our online daily news site, *Science*NOW. I'm Sarah Crespi. You can check out the latest news, our upcoming live chats, and the policy blog, *Science*Insider, at news.sciencemag.org.

Music

Host – Linda Poon
And that concludes the November 8th, 2013 edition of the *Science* Podcast.

Host – Sarah Crespi
If you have any comments or suggestions for the show, please write us at sciencepodcast@aaas.org.

Host – Linda Poon
The show is a production of *Science* Magazine. Jeffrey Cook composed the music. I'm Linda Poon.

Host – Sarah Crespi
And I'm Sarah Crespi. On behalf of *Science* Magazine and its publisher, AAAS, thanks for joining us.

Music ends