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Music

Host – Stewart Wills
Greetings, and welcome to the *Science* Podcast for October 21st, 2011. I'm Stewart Wills.

Host – Kerry Klein
And I'm Kerry Klein. This week: a pre-Clovis mastodon kill site, globalization and the evolution of West Nile virus, and the case for and against sterile neutrinos; plus, a few stories from our online daily news site.

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Host – Kerry Klein
Until recently, the so-called Clovis complex -- a characteristic assemblage of prehistoric artifacts generally dated to around 13,000 years before present -- was thought to represent the earliest well-established human culture in North America. In the late 1970s, however, evidence of earlier hunters at a mastodon kill site in northwest Washington state challenged this claim—but the issue was far from settled. Revisiting these artifacts, a team led by Michael Waters of Texas A&M University used modern methods such as CT scanning and DNA sequencing to date this site firmly to 13,800 years before present. That date suggests that humans in North America had developed weapons and hunting techniques nearly a millennium before humans of the Clovis era appeared. Waters spoke with me about the work from his office in Texas.

Interviewee – Michael Waters
In the 1970s, Carl Gustafson excavated a mastodon in Northwest Washington, and at that site, known as the Manis site, he discovered a remarkable artifact, and this was the tip end of a bone projectile point that was embedded in one of the ribs of the mastodon. And Gustafson got some radiocarbon dates from around the mastodon, and it dated 14,000 years ago. And, at the time, that was controversial, and the age was disputed, as well as the archeological evidence. So, what we did is we proposed a new study on the important specimen – the rib with the bone embedded in it. We did radiocarbon dating using atomic accelerators that was headed up by Tom Stafford. And very precise bone dating placed the specimen at 13,800 calendar-years ago. We took the bone down and did CT scanning, which is just high-resolution X-rays through the specimen, and determined that

we could show that the object was, indeed, shaped to a point – a needle-like point. And then Eske Willerslev and his laboratory examined the bone point itself and discovered that it had actually been made out of a mastodon bone. So, that meant that whoever killed the Manis mastodon had also killed or scavenged some bones from another mastodon. So, this all just adds to the growing knowledge of pre-Clovis occupation of the Americas.

Interviewer – Kerry Klein
Okay. So, you mentioned that this find was particularly controversial in the '70s when it came out, and then you just mentioned pre-Clovis civilization. So, can you kind of just go through the conventional theories on where humans stood in this time period, and sort of what this Clovis complex was?

Interviewee – Michael Waters
You know, essentially, what Clovis is is a complex, and what that means is Clovis is made up of a distinctive assemblage of artifacts, which includes distinctive spear points, blade-like tools that were made from distinctive flakes that were driven off blade cores, as well as osseous technology in which they made tools out of antler, and bone, and ivory. And this assemblage of artifacts were made all over what is now the United States and into northern Mexico. And, also, too, it dates to a very prescribed time period, roughly around 13,000 years ago to about 12,700, 12,600 years ago. And there's been a long-held belief that these people represented the very first people to enter the Americas.

Interviewer – Kerry Klein
And, so, this site where you found this mastodon, is in an area known to have been occupied by people, by humans, during this Clovis complex. So, where is this kill site?

Interviewee – Michael Waters
The site itself is located in the northwestern part of Washington. It's actually located just north of the Olympic Mountains, very close to a little town called Sequim, so it would actually be northwest of Seattle. And there's been some Clovis material recovered from the state of Washington, but this represents probably one of the earliest sites known from Washington state.

Interviewer – Kerry Klein
How precise are these radiocarbon dates that you used on these artifacts?

Interviewee – Michael Waters
Oh, at Manis, it's impeccable. The radiocarbon dating was done by Tom Stafford. He utilized the XAD technique in order to extract the collagen, and then purify the collagen to yield reliable ages. We now have something like nine ages that we obtained, not only from the rib itself, but also from various elements of the mastodon. And we've also investigated any avenues of contamination of specimens, and any other kind of things that might have affected the radiocarbon age. So, we can clearly say, beyond a shadow of a doubt, that that specimen does date to 13,800 calendar-years before present.

Interviewer – Kerry Klein
And you also mentioned a CT scan. What other analysis did you do on these bones and artifacts?

Interviewee – Michael Waters
The CT scanning was really neat. What they do is – they're basically digital X-rays, but the digital X-rays are very closely spaced to one another – in fact, each one of these digital X-rays was sliced through the bone, from one end of the bone to the next, at a distance of 0.06 millimeters – I mean, that's really small, like the thickness of a piece of paper. And, so, with all these digital images that go through this, they were able to turn it into a three-dimensional representation of what was hiding and lurking, embedded within the bone. And what you saw is that on the top, you can see the shaft of the broken projectile point, and then it goes into the bone, and it tapers down to a very sharp tip. And when the impact occurred, the tip broke off and kind of rotated off about 90-degrees. So, very clearly, what was exciting is you could see that this was a bone projectile point that had been sharpened to a tip. And, then, the other thing that was interesting is Eske Willerslev and his research group in Denmark took some samples from the actual projectile point, analyzed it for DNA, as well as did bone protein analysis, and clearly showed that it was mastodon bone. And, so, that means that the people that are roaming around at 13,800 years ago were hunting other mastodons, or at least scavenging bone from these mastodons, and making bone artifacts, tools, and weapons, and then utilizing them to continue the hunting of other mastodons, which is pretty exciting.

Interviewer – Kerry Klein
So, what does all this tell us about the civilization that may have killed this mastodon?

Interviewee – Michael Waters
You know, this is just another piece of evidence showing that people were in the Americas before Clovis. And the evidence that we're finding of these early peoples is not Clovis. You know, Clovis shows up very clearly as a clear archeological signature in the record around 13,000 years ago, but at 13,800 years ago, we have sites like the Manis mastodon, you know, in which we have no Clovis artifacts, but we have a butchered elephant, and with it we find a bone projectile point. But there's other sites that are also old, that are reliable sites, scattered across North America, and that would include Paisley Caves – dated to 14,100 years ago – and the Schaefer and Hebior sites in Wisconsin – it's dating around 14,200 to 14,800 years ago – and, of course, Meadowcroft Rockshelter in Pennsylvania – dating to about that same time period. I just recently reported on the Debra L. Friedkin site in Texas, which date us around 15 or 15,5000 years ago. And the really interesting thing about this is that, I think, a pattern is beginning to emerge, in that when you look at it together and you find bi-phase technology, you find blade and bladelet technology, and now, with the Manis mastodon site, we have osseous technology – bone technology – in North America before Clovis. And it's all the kinds of artifacts and technologies that you would have to have, you know, in the New World, from which Clovis could eventually evolve and develop from. The other thing I'd just like to point out is that kind of an interesting part of this story is the Pleistocene extinctions. During the late Pleistocene, and during the Pleistocene, there were a lot of different animals

roaming around North America that are no longer here, like the mammoth, and the mastodon, and camels, and horses, and all sorts of things. And there has been some evidence that showed that these mega-faunal populations were in decline, especially mammoth and mastodons, starting around 14,800 years ago, and probably a result of climate change, and the vegetation shifts that were taking place, and these animals were under stress. But, also, we can clearly see now that there were some hunting pressures on these animals, because we have the Manis mastodon site, and evidence that these people were hunting other mastodons, because they were making their weapons out of mastodon bones, all dating to the pre-Clovis time period. So, there were clearly hunting pressures on these animals earlier than we ever thought.

Interviewer – Kerry Klein
So, this has been a very active debate since this discovery – well, since many of these discoveries – in the '70s, and at other times. What arguments are used by the camp that still believes that Clovis were the earliest humans in the Americas?

Interviewee – Michael Waters
You know, back in the '60s and '70s and '80s, some of the criticisms that were levied against these sites were fair criticisms, and it's just that now we have better technologies, so we can go back to a lot of these sites and reevaluate them. And, then, what we're finding when we're going back – at least in the case of Manis, it does hold up to scientific scrutiny, now, with new datasets. Now, we've clearly dated the time interval of Clovis pretty tightly. We know that there are sites in South America that date to the same time period as Clovis. So, as a consequence, both continents were occupied at the same time, so there's no time for Clovis folks to get to South America, or their descendents. And you have a bunch of credible sites showing up that are dating before Clovis, all the way back to roughly around 15,000 years ago – 15,500 years ago. And all the genetic evidence is also pointing out that people entered the Americas around 15 or 16,000 years ago. So, I'm not sure what their criticisms will be, or how they'll try to interpret this evidence, but I can't explain what they would be believing in to hang on to that old philosophy.

Interviewer – Kerry Klein
Well, Michael Waters, thank you so much for speaking with me.

Interviewee – Michael Waters
Oh, sure.

Host – Kerry Klein
Michael Waters is lead author of a paper entitled, "Pre-Clovis Mastodon Hunting 13,800 Years Ago at the Manis Site, Washington," published this week in *Science*.

Music

Host – Stewart Wills

How did the West Nile virus establish itself so effectively in the Americas? First detected in New York City in 1999 after being introduced from Eurasia, the virus quickly spread across both North and South America, adapting to infect local mosquitoes more efficiently than the originally introduced strain. Studying the virus' common hosts and preferred environments, A. Marm Kilpatrick discusses in a Review this week the factors that led to this pathogen's success and assesses what we know about its future prospects. He spoke with me about this topic. I first asked him why we should pay attention to West Nile virus now, given that the virus's North American peak seems to have taken place nearly a decade ago.

Interviewee – A. Marm Kilpatrick
I think it's important to think about West Nile virus now, because, although you're correct in that the most intense epidemics in North America were in 2002 and 2003, we don't really know whether the decline in the number of cases that we've seen since then is due to a long-term trend that will continue and we won't have any more bad epidemics in the future, or, if, in fact, climatic conditions are driving West Nile virus, and we'll get conditions that lead us to a severe epidemic sometime in the future.

Interviewer – Stewart Wills
So, essentially, part of this is driven by concern about climate change?

Interviewee – A. Marm Kilpatrick
It's partly climate change, but even just normal year-to-year variation in climate if there was no climate change. We don't fully understand now how climatic conditions influence the transmission of West Nile virus.

Interviewer – Stewart Wills
Okay, well, can you remind us what this virus is like – it's epidemiology, it's effects, how it spreads?

Interviewee – A. Marm Kilpatrick
Sure. West Nile virus is a single-stranded RNA virus that is transmitted between mosquitoes and birds, and is found mostly, in the past was found in Africa, occasionally in Europe, and in parts of Asia. And, in fact, a type of West Nile virus was also found in Australia. And, then, in 1999, it arrived in New York City.

Interviewer – Stewart Wills
Okay. And can you just talk a little bit about how it's spread since its arrival in North America?

Interviewee – A. Marm Kilpatrick
Sure. So, one of the things, I think, that's really interesting about West Nile virus is it was first detected in 1999 in North America, and subsequently spread across the country really quickly. So, just in four years, it was found all the way on the west coast, and then in not that much longer, it was actually found all the way near the southern tip of South America. And, so, the virus was able to spread from one part of the northeast of the U.S.

all the way throughout North, Central, and South America in just a period of less than a decade.

Interviewer – Stewart Wills
And this virus has some pretty baleful affects, if I remember correctly.

Interviewee – A. Marm Kilpatrick
Yes. So, the virus can cause illness in humans, as well as can infect and kill a number of different bird species, and even some other mammals like horses, or, it can also even infect amphibians and reptiles.

Interviewer – Stewart Wills
Well, one particularly interesting thing that your review brought out – at least to me is – in thinking about the introduction of diseases like West Nile virus is the role of globalization. What do we actually know about that?

Interviewee – A. Marm Kilpatrick
So, people have wondered how did West Nile virus get to North America, or to New York, in 1999? And the short answer is we don't really know, but from looking at the ways that West Nile virus could have been brought to North America, and the changes that have occurred in those pathways, we have some idea that it's possible that globalization – basically, the movement of people and commodities – trade and travel – may have facilitated that introduction. And what I mean by that is that the ways that West Nile virus likely made it to North America are either on a mosquito on an airplane – it turns out that mosquitoes hitchhike on airplanes relatively frequently - or it could have been brought over by an infected either bird or some other animal through trade. Then it's possible, though actually seems highly unlikely, that it actually reached North America by a migrating infected bird. So, there simply are not that many birds that migrate from places in the Old World where they would become infected and would arrive in North America. And the coincidence, the notion, that our first detection of West Nile virus was in New York near a couple very large airports kind of lends some support to the idea that it might have got there via trade or travel.

Interviewer – Stewart Wills
And once the virus makes this trip, I think another striking thing about the story you tell in this review, is that the experience with the virus tends to be very different in different parts of the world.

Interviewee – A. Marm Kilpatrick
Yes. So, the one thing that was very interesting when kind of zooming out and thinking about West Nile virus in the broader context is looking at transmission of West Nile virus in Africa, Europe, and North America where we've done a number of studies that really allow us to know something about what's going on. And the striking thing is that in Africa, West Nile virus transmission is very intense, and, in fact, there's been a number of studies that have shown that in some populations of people, over 80% of people have been exposed to West Nile virus by the time they reach 20 years old. Whereas, in

contrast, even in North America, where we think of transmission as being relatively intense, the fraction of the population that's exposed is much, much lower. And, so, this may have something to do with simply the sociological conditions of people living in North America versus Africa. I think probably people simply get bitten by more mosquitoes in many parts of Africa. And, then, one other contrast that's also interesting is a contrast between Europe and North America. And West Nile virus has occurred in North America in a number of years – there's been a number of small outbreaks – but we've never seen kind of the repeated transmission of West Nile virus in year after year after year, like we've seen in North America since it arrived in 1999, and so it's been more sporadic in Europe than it is in North America.

Interviewer – Stewart Wills
Well, what about the lethality of the virus? I mean, is that any different in these areas?

Interviewee – A. Marm Kilpatrick
The data that we have so far suggests that, in fact, there may be no difference, in terms of the morbidity and mortality caused by West Nile virus in North America versus, say, Europe or Africa. One big difference, of course, is that we have relatively few mosquito-borne diseases in North America, whereas, in Africa, there's many things, like malaria or things like that, that you can become infected with, and, therefore, the additional morbidity to mortality caused by West Nile virus probably is just being missed by being kind of swept under the carpet of these much more important and much more frequently infecting diseases.

Interviewer – Stewart Wills
Well, you also highlight the importance of land use, especially anthropogenic land use patterns, in the spread of West Nile virus, and other pathogens.

Interviewee – A. Marm Kilpatrick
Yes. So, one interesting pattern that's arisen in several different studies is that it appears that transmission of West Nile virus may be more intense in urbanized landscapes, or in agricultural landscapes, than in natural landscapes in many different parts of the U.S. We don't fully understand the mechanisms behind that, but what it suggests is that the virus is actually taking advantage of, or being transmitted by, mosquitoes and birds that do well around people. And so it looks like this elevated transmission may be partly a result of the fact that it associates with, or is being transmitted by, birds and mosquitoes that have also been helped out by human land use.

Interviewer – Stewart Wills
So, the virus, obviously, depends on its interactions with its hosts. Have we learned anything interesting about that side of the spread of this virus?

Interviewee – A. Marm Kilpatrick
We have. So, one of the most striking things, I think, that I've found from some of my research, and other people's research have corroborated this story, is that West Nile virus appears to take advantage of one species of host in particular, and that's American robins.

And the reason why American robins are so important is because mosquitoes appear to feed preferentially, or they feed on robins much more than we would expect from the abundance of robins, and, as a result, robins appear to play a major role in West Nile virus transmission across many different regions of the U.S.

Interviewer – Stewart Wills
Well, viruses, obviously, constantly evolve. How has West Nile virus changed since it entered the U.S.?

Interviewee – A. Marm Kilpatrick
That's a very interesting question. The virus that arrived in New York in 1999 – we've actually sequenced the full genome of that virus – and it turns out to be quite similar to a virus that was circulating in the Middle East just in the previous year. But, just a couple years later, people were studying the genetics of the virus, and, in fact, detected that the virus had evolved locally. And some subsequent studies done have shown that that strain of the virus that evolved locally in North America is actually more efficient at infecting and being transmitted by two different species of mosquitoes that play an important role in West Nile virus transmission across North America. And the result has been that this newly-evolved strain actually has completely displaced the original introduced strain in just a few years.

Interviewer – Stewart Wills
Well, let's step back and put some of these things together. I mean, we've talked about a lot of different aspects of the virus and how it spreads, about the impact of globalization and land use. What would you say are the most important things we can learn from the experience we've had from West Nile virus in understanding and predicting future outbreaks, both of this virus and of ones we might not have even heard of yet?

Interviewee – A. Marm Kilpatrick
I think there's a few salient points that we've learned from about a decade of research on West Nile virus. The first thing that I think we can anticipate is that there will be future introductions of viruses that are not presently in North America, and, in fact, it's quite likely that viruses that are in North and South America will be introduced into Europe or other places in Asia or Australia or Africa. And, so, the question then becomes how will those viruses do? Will they take off and be transmitted locally, or will they kind of die out? And I think the answer to that question depends crucially on the ecology of the virus and its interactions with vectors and hosts. And, so, one of the things we learned from studies of West Nile virus is that mosquitoes actually don't feed just on hosts in proportion to their abundance, which basically means that going out on the landscape and saying who are going to be the most important hosts for a virus is actually a little bit tricky. You actually have to ask the mosquito who they feed on to really answer that question. And, so, I think, looking forward, if we want to know whether, in fact, new viruses will be able to establish and cause epidemics in North America, we need to understand the relationships between mosquitoes and the hosts that they feed on, and then how each of those two species, or sets of species, of mosquitoes and hosts, how infectious they are, or how well the virus can replicate in them.

Interviewer – Stewart Wills
So, there's a sort of a larger ecological approach that has to be taken there?

Interviewee – A. Marm Kilpatrick
Exactly. So, that's one really important thing we've learned from studies of West Nile virus in the past decade. The other thing that we've learned, which I think is not surprising, but also is very important to keep in mind, is that when a species is introduced into a new habitat, or a new region, frequently that species may evolve, and they basically change to adapt to its new surroundings. And, so, we have strong evidence of that occurring with West Nile virus, and there's no reason to think that if another virus was introduced, it might also evolve and change a little bit in its first few years when it arrives in this region of the world.

Interviewer – Stewart Wills
Well, it sounds like quite a challenge. Marm Kilpatrick, thanks very much.

Interviewee – A. Marm Kilpatrick
Thank you.

Host – Stewart Wills
A. Marm Kilpatrick discusses the evolution and spread of West Nile virus in a Review article in this week's *Science*.

Music

Host – Kerry Klein
In a News Focus this week, *Science*'s Adrian Cho explores the evidence for and against the existence of the sterile neutrino, a hypothetical subatomic particle that's causing quite a stir in the physics community. Following a conference last month devoted to the elusive particle, believers and skeptics are no closer to an agreement, but have come up a few methodologies that may help to detect the particle. Cho spoke with me about the story and began by explaining just what the difference is between ordinary and sterile neutrinos.

Interviewee – Adrian Cho
So, an ordinary neutrino is a subatomic particle that comes out of a kind of nuclear decay called weak decay, and the principal example of this is a neutron can decay into a proton by emitting an electron and an antineutrino. And the neutrino – or the antineutrino, in this case – is nearly massless and barely interacts with other matter at all – it only interacts through these weak interactions. And a sterile neutrino would be an even weirder beast, because a sterile neutrino would not interact at all – it would have no weak interactions, period.

Interviewer – Kerry Klein

So, if these sterile neutrinos don't interact with anything at all, how could they, how could they even exist?

Interviewee – Adrian Cho
So, ordinary neutrinos come in three flavors. There's the electron neutrino that's born in this kind of weak decay of neutrons, but there are also two other types of neutrinos. There's a muon neutrino, and a thing called the tau neutrino. And physicists have known since about 2000 – although they've suspected it for much longer – that when a neutrino of one type, or flavor, is zinging along, it can morph into one of these other flavors, and that changes the types of interactions it can have. And, so, that's known as neutrino oscillation, or neutrino mixing. And sterile neutrinos would come in, because the only way you could get to a sterile neutrino is if you had an ordinary neutrino going along, and it morphed into the sterile neutrino, and then, perhaps, at some other point, it would morph back into an ordinary neutrino. And the reason that people suspect that these sterile neutrinos are out there is basically if that process happens, then you should see evidence of ordinary neutrinos disappearing in a kind of unexpected way, or appearing out of nowhere in a surprising way. And there are tantalizing hints, basically, that neutrinos are either going missing, or are appearing where they're not supposed to be. And that's basically the idea of why physicists think there are sterile neutrinos out there.

Interviewer – Kerry Klein
Okay, so, the sterile neutrino is brought in to describe a few of these phenomena that we can't necessarily explain otherwise. What are some other lines of evidence out there for why these sterile neutrinos would exist?

Interviewee – Adrian Cho
Well, so, there are basically three main lines of evidence. The first is from a detector called the Liquid Scintillator Neutrino Detector at Los Alamos National Laboratory. And what the LSND researchers did is they used a particle accelerator to generate a beam of muon antineutrinos, and they shot it about 30 meters into this detector, which was outfitted with light detectors to detect particle interactions. And so what these guys saw was that over 30 meters, there appeared to be a significant number of muon antineutrinos appearing as electron antineutrinos, and that was kind of a mysterious thing. Now, you might say, "Well, gosh, if physicists already suspected that neutrinos could morph from one flavor to the next, why is this a surprise? You should expect it." The problem was that the rate at which these oscillations between the three ordinary neutrinos takes place can't account for this observation that LSND saw. So, what the physicists found, though, is that they could explain the results if their muon antineutrinos were first turning into sterile neutrinos, and then turning back into electron antineutrinos. So, that was sort of the first line of evidence. A second line of evidence is from studies of cosmology from the afterglow of the Big Bang, which is known as the cosmic microwave background, and the distribution of the galaxies. Cosmologists can infer how much radiation was in the early universe after the Big Bang, and it turns out that light neutrinos act like an additional form of radiation. And it turns out that the data right now, with a fairly high uncertainty, points to about four. So, that data suggests that there's a fourth neutrino out there. And scientists know that there isn't a fourth ordinary neutrino out there, so that

suggests that, perhaps, a fourth neutrino is a sterile neutrino. And, then, the third major prong of evidence is a recent calculation that came out just this year that suggests that nuclear reactors may actually be putting out slightly more antineutrinos than previously thought, and also that the rates that are seen in detectors may actually be a little lower than they ought to be – these detectors have been placed a few tens of meters away from these nuclear reactors. If that rate is too low, then it suggests that some of those antineutrinos are disappearing, and perhaps they're turning into sterile neutrinos. So, those are the three basic lines of evidence – from particle physics, from cosmology, and from nuclear reactors.

Interviewer – Kerry Klein
Well, on the other side of the coin, what are some of the lines of evidence used by skeptics of the existence of this sterile neutrino?

Interviewee – Adrian Cho
I think what makes the sterile neutrino interesting is the fact that it's this really kind of tantalizing puzzle, right, because there are these pieces of evidence from three different directions that all suggest that there are these sterile neutrinos out there. And that's actually kind of exciting, right? I mean, there could be this whole new, very weird, particle out there that has no interactions, basically, at all. The thing that makes it even more interesting is that it's not exactly clear that all these clues point in the same direction, so it's not clear that this case really holds together. For example, the LSND experiment saw these electron antineutrinos appearing where they weren't expected. An experiment known as MiniBOONE, which ran at Fermi National Accelerator Laboratory, they tried to see the exact same thing using, instead of muon antineutrinos, muon neutrinos, and they did see some electron neutrinos appearing in their muon antineutrino beam, but they were at the wrong energy, so they couldn't have been the same process that LSND was seeing. So, that put in this very interesting crimp, which, it appears that the phenomenon LSND saw only appears in antineutrinos and not so much in neutrinos. If that's the case, it turns out there has to be two types of sterile neutrinos, not one. And, similarly, this cosmological data suggests that there's another neutrino out there. But it turns out that if you probe it a little bit, the cosmologists don't really care if this light extra particle is a true neutrino – it could just be some really feebly interacting particle that doesn't have all the technical properties of a neutrino. So, it's an interesting case, in that you have these very tantalizing pieces of evidence, and they all point to this really weird particle, but it's not clear that all the bits of evidence line up. So, there's a real debate about how persuasive this case is.

Interviewer – Kerry Klein
So, did anything come out of this workshop that may eventually put this debate to a close?

Interviewee – Adrian Cho
Well, one of the things that's intriguing about this problem is that, in principal, it should be possible to resolve this question for relatively little money, in terms of particle physics experiments. So, basically, if there is this sterile neutrino out there that ordinary

neutrinos can oscillate and change into very quickly over a distance of tens of meters, then, in principal, if you have a beam, say, of muon neutrinos, then you should see the number in them go down and up, and down and up, as the neutrinos fly. And if you saw that, that would be a complete smoking gun that there is this new type of neutrino out there. So, there's a proposal to either build a new detector for the MiniBOONE experiment at Fermilab, or just move the present detector and see if you still get the signal, and if the rate changes. And a number of experimenters told me that that was basically a no-brainer, that that experiment really ought to be done, because building a new detector would cost about $10 million, moving the present one, apparently, would cost about $5 million. And that's not a huge amount of money, in terms of particle physics, or science in general, these days. It also turns out that if you took a radioactive source, which would be a very intense source of electron neutrinos, and you stuck it in a big neutrino detector that could actually identify where a neutrino underwent an interaction, then you could actually see within the single detector the rate of electron neutrino identifications go up and down as the distance from the source increased. There, though, the questions are sort of a more bureaucratic nature. You know, this would have to be a pretty intense source of radiation, so there are all kinds of regulatory hurdles about assembling that kind of a source, transporting that kind of source. And so that experiment seems simple – nothing like this has been approved yet – but it has these kind of regulatory challenges, as well. So, one of the things that was interesting about this workshop is that there is the chance that if you could scrape together a relatively small amount of money, you could actually put this idea to the test. And the researchers at this meeting are trying to put together a white paper to kind of lay out the options. I mean, I think it's fair to say there's enough skepticism that, given the relatively tight budgets that the science programs of all sorts are under right now, even putting together a few million dollars may not be the easiest thing in the world, but it is tantalizing that the matter at least could be tested pretty stringently for a not huge amount of money.

Interviewer – Kerry Klein
Tantalizing, indeed. Adrian Cho, thank you so much for speaking with me.

Interviewee – Adrian Cho
Sure, my pleasure.

Host – Kerry Klein
Adrian Cho discusses the debate surrounding the sterile neutrino in a News Focus this week.

Music

Interviewer – Stewart Wills
Finally, today, David Grimm, the online news editor of *Science*, is here to fill us in on some recent stories on our daily news site. So, first, David, a robotic look at the evolution of bird flight.

Interviewee – David Grimm

Right, Stewart. This story is all about how a tiny robot could solve a very big biological mystery. And that mystery is what good would a primitive wing have done? I mean, obviously, full-fledged wings are very useful, they allow birds and other creatures to fly around in the sky. But, wings just didn't appear out of nowhere, there must have been some sort of proto-wing. And the question is, what use would that have served?

Interviewer – Stewart Wills
So, where do the robots come in, in solving that problem?

Interviewer – David Grimm
Well, the robots come in in trying to help researchers decide which of two hypotheses make the most sense. One hypothesis basically says that flying evolved from gliding, that animals were sort of gliding down from the trees, they would need some sort of wing-like structure to do that – not necessarily a structure that would let them flap around and fly, but would help them glide better. This is called the "trees-down" idea. The other one is called the "run flap" idea, and the idea with this is sort of more of a ground-up situation where animals would be flapping a wing-like structure while they ran across the ground, and this might help them get over obstacles better, or steep inclines. The funny thing is that the engineers that created this robot had no interest in this biological question. They were just sort of – they wanted to create a cool robot for the U.S. military to help it sort of spy, and do all the things that the U.S. military does, and, basically, they created this tiny little 25 gram robot that has a pair of wings that can flap around. The robot doesn't fly, but the wings do sort of all the other things that normal wings do. And, when they heard about this biological debate, they said, "Hmmm, I wonder if our little robot could help solve this problem?" And, so, what they did was they ran the robot through basically a mini-Olympics obstacle course, and they had the robot do things like, you know, gliding from one object to another, but also running very quickly across the ground, and trying to see if these wing structures helped the robot get over certain obstacles, like some scientists had posited might have happened with early winged animals. And you can actually see a video of this happening on the site, it's actually kind of fun.

Interviewer – Stewart Wills
So, what do these videos show?

Interviewee – David Grimm
Well, the video basically shows that flapping wings seem to help a lot with all of these tasks – with the gliding, and with getting up steep inclines, and actually getting over obstacles, as well. But, they helped with gliding most of all. So, in terms of, you know, the flapping while these robots were running on the ground, they were able to increase their speed by about 90%, but they would need to increase their speed by 400% to actually fly, which indicates…

Interviewer – Stewart Wills
To get off the ground.

Interviewee – David Grimm
Get off the ground, exactly. So, it indicates that maybe these wings weren't so useful for early flight, or the development of flight, but when it came to gliding, it turns out, these robots were able to sail much farther from one object to the next when they were flapping these wing-like structures than when they weren't. So, at least according to the work done with this robot, the researchers are saying, you know, we really think that it's these wings that were important for gliding.

Interviewer – Stewart Wills
Trees-down, rather than ground-up.

Interviewee – David Grimm
Exactly.

Interviewer – Stewart Wills
And, next, a certain amount of plasticity in teenage IQs.

Interviewee – David Grimm
Right. Well, this study, Stewart, is about IQ, which is kind of a controversial concept. A lot of scientists dismiss the idea that IQ actually really means anything about our innate intelligence. But, what a lot of researchers do agree on is that IQ does seem to be predictive for our ability to learn, to perform certain tasks, and it even may be somewhat predictive of our later academic achievement and job performance. So, there is some importance to IQ, nobody's really sure what it is. But this study's really not about what does IQ mean, it's does IQ change? There's been a debate in the scientific community about whether IQ changes over time, or whether basically once your IQ score is set, that's basically your IQ for your life, no matter sort of what you do.

Interviewer – Stewart Wills
And, so, someone set up a way to test that?

Interviewee – David Grimm
Exactly. And they tested it on teenagers. They looked at 19 boys and 14 girls, and they tested these kids in both 2004 and 2008. And what they did was they gave them some tests that would test IQ, and, at the same time, they had them sit in these MRI machines, which measure…

Interviewer – Stewart Wills
Magnetic Resonance Imaging.

Interviewee – David Grimm
Exactly. And this measures brain activity. And while the teenagers were in there, they were performing verbal tasks, like reading or naming objects. They were also doing non-verbal tasks, like solving puzzles with their hands. And the idea was to see if there was a correlation between IQ and how they were doing on these activities, and any sort of differences in brain activity or brain structure. And, actually, what the researchers found,

which was really surprising, is that the IQ varied by as much as 20 points between the two times that these kids were tested between 2004 and 2008. Whereas, before, people were saying, you know, IQ is probably just set, this team was showing that it wasn't set, that it was kind of flexible. Not only that, but there was also differences in the grey matter of these kids, and that seemed to correlate with higher IQ scores – the bigger the IQ score, the more the kid seemed to have an increase in grey matter density, and this grey matter correlated to particular parts of the brain that were involved in the tasks they were doing, so that if a kid was doing better on speech, or had a better IQ speech score, the grey matter in this region would be higher.

Interviewer – Stewart Wills
Well, that 20 points is pretty significant. I mean, the average IQ is 100 points, right?

Interviewee – David Grimm
Exactly, exactly. So, these are really big differences. And the researchers say why this is important is because if IQ is not fixed, it could mean that there are ways to intervene. So, if IQ is really tied to things like future success in your job or academics, you're not necessarily stuck with the IQ that you have. If you have a lower IQ, perhaps you could do something to improve it.

Interviewer – Stewart Wills
So, this means that adolescents, at least, can potentially boost their intelligence, or at least whatever it is that IQ measures as intelligence. What about the rest of us?

Interviewee – David Grimm
And that's a great question, Stewart. And that's something the researchers are looking at now, whether it's not just the adolescent brain, but the brains of the rest of us, you know, can be malleable, as well.

Interviewer – Stewart Wills
And, finally, obesity may depend on the neighborhood you live in, it appears.

Interviewee – David Grimm
Right. Well, this next story is kind of controversial. It suggests that just the neighborhood you live in can determine things like obesity and diabetes. And this has been an idea that's been around, actually, since the 1920s, the idea that if you maybe live in a poorer neighborhood, you're more prone to obesity, and diabetes, and other problems, than if you live in a middle class neighborhood. Now, it kind of makes sense, but with issues like this, it's always a question of correlation versus causation. You know, are people that live in bad neighborhoods, are they in these neighborhoods because they're already predisposed to these conditions, and the neighborhood doesn't really make much of a difference? Or is the neighborhood itself actually playing an active role, as much as a neighborhood can play an active role, in these problems?

Interviewer – Stewart Wills
So, how would you sort such a thing out?

Interviewee – David Grimm
Well, it turns out that actually the U.S. Department of Housing and Urban Development, which is responsible for housing issues for the U.S. government, actually carried out an experiment in the 1990s where they took people that were from poorer neighborhoods, and they gave some of them rent vouchers which allowed them, if they wanted to, to move out of that neighborhood, move into a middle class neighborhood, and not have to pay any extra money. Some of them took the rent vouchers and did that, some of them kept the money and they just stayed in the lower class neighborhood, and some of them didn't get any rent vouchers at all. And, during this whole period – this was about a four or five year study – another group of researchers also stepped in and measured the health of these people. They took their height, their weight, and they actually even looked at their blood. They looked at the amount of hemoglobin in the blood that was bonded to sugar molecules, and this is an indicator for diabetes.

Interviewer – Stewart Wills
And, so, what did they find from looking at all of this?

Interviewee – David Grimm
Well, they found that, indeed, neighborhoods matter, that people that moved into middle class neighborhoods from the lower class neighborhoods were about 5% less likely to become obese and show signs of diabetes. Now, 5% may not sound like a lot, but a lot of the drugs that are out there that target weight and diabetes don't actually do much better than that, which is really interesting, because it means that simply moving to a different neighborhood can be as effective as taking some weight-loss and diabetes drugs.

Interviewer – Stewart Wills
Well, I suppose moving to a different neighborhood might be a little harder than taking a drug.

Interviewee – David Grimm
Exactly. That is very true, and a lot more expensive, potentially.

Interviewer – Stewart Wills
What's behind these effects?

Interviewee – David Grimm
Well, that's the next question. So, now, researchers feel that they've actually shown that there is an effect of neighborhoods, and this is an active effect – this is causation, not just a correlation – but there's still a big question about why this would be the case. Is it the case that, you know, people in middle class neighborhoods, maybe there's more open space, there's less crime, and so you're more likely to be walking around outside, and you're going to lose weight, and that's going to be healthier for you? Or maybe there's just healthier people around you – there's thinner people, there's people that are in better shape – and maybe that rubs off on you, there's some sort of, you know, health peer pressure going on, and people are more likely to live a healthy lifestyle that live in those

neighborhoods. So, that's the next step, to figure out exactly what's going on. But for right now, they've got this really interesting finding that they can build on.

Interviewer – Stewart Wills
Okay, Dave, so what else are you looking at for the news site?

Interviewee – David Grimm
Well, Stewart, for *Science*NOW, we've got a story about poisonous seaweed. Also, we will be announcing the winner of our 2011 Dance Your Ph.D. contest. This is a yearly contest we run which invites grad students, and scientists, and post-docs – anybody who's got a Ph.D. – to dance…

Interviewer – Stewart Wills
And a bottle of whiskey.

Interviewee – David Grimm
Exactly, exactly, and who is not too self-conscious to actually get in front of a camera and interpret their Ph.D. in dance form. We've been doing this for a few years, it's a lot of fun. You can go on the site and you can see all of the videos from the entrants. You can see our finalists. And, today, you can actually go on the site and figure out who won the contest from over the 50 entries that we had. And for *Science*Insider, *Science's* policy blog, we've got a story about what's going on with stem cells in Europe. Also, about desperate times at the National Institute of Health, and how the institute is reaching out to scientists to figure out ways to best deal with the budget crunch that it's facing. And, finally, for *Science* Live, our weekly chat on the hottest topics in science, this week's chat is about the science of cloaking. So tune in to ask experts questions about how to make things disappear.

Interviewer – Stewart Wills
That's right. I hope you have some Romulans.

Interviewee – David Grimm
Right. So be sure to check out all these stories on the site.

Interviewer – Stewart Wills
David Grimm is the online news editor of *Science*. You can check out the latest *Science* news, and the policy blog, *Science*Insider, at news.sciencemag.org, where you can also join a live chat, *Science*Live, on the hottest science topics every Thursday at 3 p.m. U.S. Eastern time.

Music

Host – Stewart Wills
And that concludes the October 21st, 2011, edition of the *Science* Podcast.

Host – Kerry Klein

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

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

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

Music ends