ORIGIN STORIES
THE LEAKEY FOUNDATION PODCAST

Episode 40: The Denisovans

Link to audio file: https://radiopublic.com/origin-stories-6VPVbG/s1!a83b1

HOST: This is Origin Stories. The Leakey Foundation podcast. I'm Meredith Johnson.

[sound from outside Denisova Cave, birds chirping, sounds of flowing water]

HOST: This is the sound of the forest in the foothills of the Altai Mountains in Siberia. Outside of a place called Denisova Cave.

I can imagine what it was like here back in the Pleistocene.

If you stood in the opening of the cave and looked out you would see a beautiful view. A sparkling river flows not far below. If you looked to the left you would see a valley which opens up to the steppe that goes more or less uninterrupted - all the way to what is now Mongolia and northern China on one side- and to Central Europe on the other. Vast herds of migratory animals like bison and horses moved through the valley, fish swam in the river, and the lush green forest spread out all around.

Some of the prehistoric people who lived in the Altai mountains came to be known as the Denisovans — and the story of their discovery - and what it means - is the topic of our episode today.

[sounds of scientists talking inside of a cave]

HOST: This is a recording from inside Denisova cave - it was taken in 2011 during a conference- Russian scientists are telling their visitors about something amazing they discovered in Denisova cave one summer day. It was an insignificant-looking little scrap of a fossil. A tiny fragment of bone from the tip of a child's pinky finger. It was about as big as a thin slice of a jellybean. But hidden in that little fragment was a secret history of

humankind.

BENCE VIOLA: I think there are a few questions that are really basic for human existence and, "Where do I come from?" is probably one of the most important ones. After what am I going to eat tonight? But where do I come from is something that people have been asking for a very, very long time. I'm sure neanderthals wondered about it sometimes as well. Why are we here? It's a very important question. The other reason for it I think is though because it matters for our lives.

HOST: That's Bence Viola. He is a paleoanthropologist at the University of Toronto and a Leakey Foundation grantee. He's part of the international research team studying the fossils from Denisova cave. And for a large percentage of people in the world today, the recently discovered Denisovans are part of the answer to the question -where do I come from?

BENCE VIOLA: So Denisova cave has been excavated since the 1980s by my Russian colleagues. And they actually, in the 80s, already they found two teeth that they assigned to hominins.

These teeth were first described in 1988 by a dental anthropologist named Christy Turner. He proposed that these two teeth are Neanderthals. This was interesting because at the time nobody had a clue that Neanderthals lived this far east.

HOST: When Viola was working on his Ph.D. dissertation, he examined these teeth from Denisova Cave and came to a different conclusion than Christy Turner did.

BENCE VIOLA: In my opinion, the two teeth were actually neither neanderthals nor modern humans, especially one of them seem just very strange. And I thought, "These are not neanderthals or modern humans."

HOST: Viola found that the tooth that didn't seem human or Neanderthal actually turned out to be a worn-down bison tooth - and that's what it said in his thesis.

After that, Viola got a postdoctoral position with Svante Pääbo and his group at the Max Planck Institute and he soon had another chance to study fossils from Denisova Cave.

The little sliver of pinky bone from Denisova arrived at Svante Pääbo's lab not long before Viola did. The Russian scientists had packaged it up and sent it there to see if Pääbo's team could get any ancient DNA from it - because, at the time, Pääbo was working on sequencing the first Neanderthal genome.

Viola meanwhile had just moved into his apartment in Leipzig Germany and set up his internet.

BENCE VIOLA: and the first email I got was from Svante saying, "Bence, you have to come to the institute immediately. I have some very interesting things to discuss with you."

Paabo's team had successfully extracted DNA from the tiny bone -

BENCE VIOLA: Then, a year after I defended my thesis, my Russian colleagues found this finger bone and they sent it to Leipzig. It's a tiny fragment of a distal phalanx. So really the tip of, likely, a pinky. Svante and his colleagues extracted DNA from it. And it came out as neither a modern human nor a Neanderthal, a completely different population.

I was thinking back to my Ph.D. and I said, "In Denisova, there's something that's neither modern human or Neanderthal, but that is based on a bovid. but this finger bone, later on, proved me right.

HOST: At first, they were only able to extract mitochondrial DNA, - a type of DNA that's inherited from the mother which only has about 16,500 base pairs, but you can learn a lot from it. For instance, you can use it to establish sort of a molecular clock and you can get an idea of when the last common ancestor of modern humans and this population lived.

BENCE VIOLA: And based on the mitochondrial DNA, it looked like it was one and a half to 1 million years ago, which was mind-blowing. You have something here that's maybe 50,000 years old, but it actually, it has the last common ancestor with modern humans more than a million years ago.

BENCE VIOLA: And so two weeks or three weeks later, we flew off to Siberia, because we felt like this is not something we can discuss with our Russian colleagues by email. It was so surprising, the result. And so we said, "We're going to come and we need to talk to you." And we flew there, and we showed them our results, and they were completely amazed, of course.

And it was truly amazing because that tiny bone was evidence of a previously unknown kind of prehistoric human. And it was the first time such evidence came from DNA. Viola's Russian colleagues had a surprise for him too. Something new from Denisova cave.

BENCE VIOLA: And then they pulled out a tooth from their pocket that I haven't seen before. I thought I've seen all the human remains from Denisova cave, but there was this beautiful, gigantic molar. Seeing that, I was like, "Oh, this is not a Neanderthal, nor a modern human's. This is clearly... The DNA is right. This is something different."

HOST: They called the fossil Denisova 4 - it's a very large upper molar - with a surface area twice as large as a modern human molar.

BENCE VIOLA: And that is Denisova 4, which is the large Denisovan molar that we described soon after. So, it was really just an amazing story. We found this population based on a fossil, this fragment of a finger bone, which, morphological, you could probably tell it's a hominoid, but I'm not even sure you could exclude that it's a chimpanzee. It's such a tiny fragment. And from its DNA, we could tell not only when it's last common ancestor with modern humans lived, but later on, we could also extract nuclear DNA, and we could show that this population, the Denisovans, were actually a sister group of Neanderthals. So, more or less, like the Asian cousins of Neanderthals, and the geneticists could also show that modern humans actually interbred with this population because we see traces of Denisovan ancestry in Melanesian populations. And then later on, now we also know that you even have it in Asian populations at much lower levels. So, the Denisovan story really shows that even extremely minute fossils can give us incredible insights into our past.

HOST: The existence of the Denisovans was announced in 2010 in the journal *Nature*. Until just a few months ago this new member of our human family was only known from that minute pinky bone fossil, a few molars, and a bit of bone so small, it's hard to tell what part of the body it came from. The sum total of all the fossils the Denisovans left

behind could easily fit in the palm of your hand.

HOST: The ancient DNA inside those fossils though - adds a fascinating new twist to our human story. And all from this one cave in the foothills of the Altai Mountains in Siberia. A cave that thanks to it's cold and stable environment, preserves DNA remarkably well.

And I want to go back to the cave those fossils came from for a bit before we move on to the astounding insights they can give us.

In January 2019, scientists published a timeline of life in Denisova cave. A detailed study of the 103 layers of sediment, the tools, bones, and other artifacts from the cave. This timeline suggests that humans - Homo sapiens, Neanderthals, and Denisovans occupied this Siberian shelter from around 300,000 years ago up until fairly recently.

BENCE VIOLA: The story is, supposedly, that there was a hermit, I think in the late 18th century, Dennis, who kind of withdrew there and moved into the cave, and people came and asked him for his wise judgment and ideas. So, it's named after him. But I also heard that this is, in reality, not really true. Wikipedia says this, but my Russian colleagues, for example, disagree.

HOST: The story of Dennis the wise hermit may or may not be true, but it is true - and there's evidence - that people did live there up until a few hundred years ago - Complicating the picture are the animals that lived there. Bronze age people kept herds of goats and sheep in the cave - something that's still done in Central Asia today. And when you keep animals you accumulate poop and parasites and things like that.

BENCE VIOLA: What they do in Central Asia, the problem is [inaudible 00:24:05] keep the animals in there, you accumulate parasites and so on. But once a year, you set it on fire and burn it out. So you have these layered deposits, ash deposits. You have these very thin layers of dark gray and light gray on top of each other. It's really beautiful, but it's bad to breathe it in, of course, because it's all burnt goat and sheep poop.

HOST: Below those layers of goat and sheep poop are older Pleistocene layers made of

cave loam. Those layers contain fossil things like stone tools, beads and other ornaments, bones with cut marks and other evidence of life in the cave.

BENCE VIOLA: We have now, in total, I think 14 or 15 hominin fragments from Denisova, and with the exception of one, all of them are smaller than two centimeters. They're smaller than an inch. So, they're all either an isolated tooth or the finger bone. And we also have a bunch of fragments that are just random, long bone fragments that were identified through a new approach using peptide fingerprinting, where you run mass spectroscopy on the collagen molecules that are in there.

HOST: Without all this new technology, and these new methods - it would be nearly impossible to make sense of the bone fragments in this cave. Why are they so tiny and fragmented? It's because of another animal that's occupied the cave.

BENCE VIOLA: But what is interesting, a lot of these fragments show traces of acid etching, and this acid Etching is likely due to the digestive tract of carnivores. The cave is full of hyenas. Especially, there are several layers where it seems to have served as a hyena den. We have the bones of juvenile hyenas, and unusually baby hyenas died during the winter in the den, and are probably eaten better rest with the group.

BENCE VIOLA: But these hyenas, they eat the bones and they usually kind of throw them up, regurgitate them or poop them out. And so likely these a little bone fragments that we find were either regurgitated or pooped out by hyenas. All these fragments, each of them is a different individual. We don't have two fragments that come from the same individual. They're all from different individuals, some from Neanderthals, some from Denisovans.

HOST: Viola says a lot of these individuals were children

BENCE VIOLA: We don't know whether the hyena just went and grabbed a kid from somewhere and took it away. They do that sometimes. Or whether they dug up dead bodies, which is a possibility as well. Hyenas are scavengers, and opportunistic, and if they smell something good rotting, they might dig it up and then bring it to their den for the babies, which is a bit of a weird picture.

BENCE VIOLA: Some of the specimens we have, for example, are not only digested, but also have a lot of hyena DNA and there's one finger bone, not the Denisova finger

bone, but Neanderthal finger bone that has a lot of Hyena DNA in it. And I kind of imagine it like a Hyena pacifier. You have this little Hyena baby who sucks on a Neanderthal finger and just spits it out. And then we find it 100000 years later. Hyenas are weird.

HOST: Hyenas aside - It looks like different groups of prehistoric people took turns living in the prime cave real estate - over and over again for millennia. The timeline of human life in Denisova cave seems to read like this - The oldest signs of human life in the cave are simple stone tools, estimated to be more than 280,000 years old.

The oldest sign of Denisovans is somewhere around 200,000 years ago and again around 50,000 years ago. Within that date range, the Denisovans likely occupied the cave several times and there's also evidence of alternating Neanderthal occupations within that time frame.

And we know they must have met up there at least once because of an astounding discovery announced in 2018 by Viviane Slon and colleagues.

VIVIANE SLON: So, my name is Viviane Slon, I'm a post-doc at the Max Planck Institute for Evolutionary Anthropology in Leipzig in Germany and I work on ancient DNA.

HOST: Slon was working with some of the small slivers of bone from Denisova cave. Colleagues of hers in Oxford and Manchester had sorted through thousands of bone fragments looking for collagen signatures that would tell them which of the bones belonged to hominins and which to other animals

VIVIANE SLON: It was really a story of persistence because this was the bone number 1,227 that they had to look at. So, that's how the bone was identified at all as a hominin bone to begin with.

HOST: The British scientists sent this bit of bone to Slon in Leipzig and she carefully drilled a few milligrams of bone powder from it and extracted some mitochondrial DNA which confirmed it was indeed from a hominin

VIVIANE SLON: so that's when it was called officially Denisova 11, but among friends, we call her Denny.

HOST: She sampled a bit more of the bone and was able to get some nice nuclear DNA. She sequenced the genome and compared Denny's DNA to that of Neanderthals and Denisovans

VIVIANE SLON: Sure, so what we found was we sequenced the genome of one ancient individual from a sight in Southern Siberia called Denisova Cave and what we realized was that this person was the daughter of a Neanderthal and Denisovan

VIVIANE SLON: And usually, what you see is that an individual matches either one or the other. But this wasn't the case for Denny. Denny was very special and what we saw was that the DNA fragments from Denny actually matched both Neanderthal variants and Denisovan variants in approximately equal proportions and that told us that she has both Neanderthal and Denisovan ancestry in almost equal proportions.

HOST: I asked her how she felt when she got those results

VIVIANE SLON: At first, I was sure it was a lab error. We're very careful in the lab, we work in a clean room, we have very specific protocols on how to handle ancient specimens, but mistakes can happen. It's not that it's completely unheard of and I was sure I'd made some kind of mistake, that there was some kind of mix up that two samples get mixed together or two DNA extracts get mixed together, something, I thought something went wrong.

VIVIANE SLON: And so, we repeated the experiment. I went back to the bone and extracted DNA again and did all the process again a total of six times in different occasions and each and every time, we got the same results, so at that point, you say, "Okay, it must be real." And if it's real, it's really exciting.

HOST - {slightly off-mic in the interview} Because it means what?

VIVIANE SLON: This individual has one neanderthal parent and one Denisovan parent, which would make it the first time that we see a daughter of two different

archaic hominin groups. It's, of course, not the only explanation that could be, so we had to do further analysis to verify that there were not other potential scenarios that could explain this.

VIVIANE SLON: For example, if her parents came from a population that we hadn't sampled yet and where everyone has both neanderthal and Denisovan ancestries. But we did some further tests and we confirmed that, in fact, what we were seeing was a first-generation, so a daughter, of a Neanderthal mother and a Denisovan father.

HOST: The odds of finding an individual like Denny are mind-bogglingly rare. And until recently it wouldn't even have been possible to pry such an amazing story from such a small fossil.

They estimate that Denny lived somewhere around 90 - 100,000 years ago. And Bence Viola was able to estimate that Denny was at least 13 years old when she died.

VIVIANE SLON: She could have been far older, but that's sort of the minimum age and that's really interesting, because it tells us that she survived past infanthood, past young childhood. Somebody was caring for her and I think that's very interesting.

HOST: Denny's story gives us some idea about the lives of the mysterious Denisovans. Thanks to her, we know that at least once, a Denisovan man met and had a baby with a Neanderthal woman.

Another exciting - recently announced discovery from Denisova cave is a section of skull that gives us a little bit more of an idea of what Denny and her Denisovan dad might have looked like.

BENCE VIOLA: So two years ago in the summer, my Russian colleagues found two fragments of a parietal bone, so the upper part of the cranium in Denisova Cave in the South Gallery. What is interesting is that these cranial fragments are quite large compared to everything else we have from Denisova. We have about 10 centimeters by seven and a half centimeters, I think, of the cranium. Which using mirroring because we have the midline of the cranium preserved, we can actually more or less extrapolate the general shape of this cranium.

HOST: Viola says the pieces don’t look very Nenaderthal like - Neanderthals had sort an oval-shaped head.

BENCE VIOLA: Now, when I first saw these pieces and we're still working on them both on the DNA and then the morphology. We had the impression that it doesn't look very Neanderthal-like. Neanderthals have, if you look at their head from the back a kind of an oval outline of their cranium. This didn't look like that at all. It looked much more angular, but it looked very low and very robust, which again is quite different from what we see in modern humans.

HOST: Working with colleagues, Viola conducted comparative studies with other fossils, including one called Kabwe from Zambia. Kabwe is one of the largest hominin skulls in the fossil record.

BENCE VIOLA: The Denisova fragments are larger than Kabwe by probably almost about 10% so it's quite a difference, which again fits with these large teeth. I never dared, just based on the teeth, to say that these are likely big guys, but I think now with the cranium, they were likely pretty large individuals. I hope that one day we'll find more postcranial remains that will allow us to tell these much more in detail.

HOST: So for now, we still don’t know much about what they looked like. But we know the Denisovans didn’t stay in that cave, and they didn’t only mate with Neanderthals. They also met up and had sex with Homo sapiens - far from Siberia.

BENCE VIOLA: Yeah. The fascinating thing with Denisovan DNA is that, [inaudible 00:07:04] again, one of these things, it was unbelievable when I first heard even that this population exists, but then the next one was that Johannes Krause, who was working on this, came up to my office. By this time I was at the Max Planck, and he said, "We found a population that actually carries Denisovan DNA." And I was thinking it was probably in Mongolia or China. And then he said, "It's in New Britain," which is an island off the coast of Papua New Guinea.

BENCE VIOLA: I was like, "This can't be right. You guys screwed up something. This 10000 kilometers away." But nope. That was the first population, and even today, we know the highest amount of Denisovan ancestry we see in Australian Aborigines, Papuas in Papua New Guinea. And there's actually also some hunter-gatherer groups in the Philippines that carry quite a bit of Denisovan ancestry.

HOST: All people alive today who are aren’t recently from Africa, carry roughly 1.5 to

2% of Neanderthal DNA. Scientists have found that some people in Papua New Guinea carry maybe even up to 5% Denisovan DNA.

BENCE VIOLA: And what was interesting in some of these groups, they actually carry more Denisovan DNA than Neanderthal DNA. All modern humans who are from outside of Africa today carry between roughly 1.5% and 2% of Neanderthal DNA. Some of these groups in Papua New Guinea carry maybe even up to 5% of Denisovan DNA. So, I would say a significant portion of their genome comes from these archaic hominins. And what is interesting is up until now, we still only know Denisovans from Denisova Cave in Siberia. But the people that carry the most Denisovan DNA are down in Southeast Asia and Melanesia.

HOST: Scientists think Denisovans were likely widespread in Asia due to these patterns of Denisovan DNA in present-day humans. There is Denisovan DNA in all East Asian populations and it's found in Southeast Asian populations.

There were also intriguing clues that Denisovans had lived in Tibet at high altitudes. Much higher than Denisova Cave. There's a gene variant that modern Tibetans carry which is different from everybody else in the world. It's a gene related to adapation for living at high altitude that allows Tibetan people to live and thrive on the high, cold Tibetan plateau at altitudes greater than 13,000 feet. An altitute that other people can't deal with, in part due to the low atmospheric oxygen pressure. A study published in 2014 by Emilia Huerta-Sánchez links that gene to the Denisovans.

Viola says it's almost identical to the one found in fossils of ancient Denisovans. That's even though Denisova cave sits at an elevation of only roughly 2500 feet above sea level.

BENCE VIOLA: The variant that Tibetans carry is very different from everybody else in the world, but it's almost identical to the one we found in the Denisovan fossil, which is just so amazing because we know that the women who carry this Denisovan-like variant have babies with a much larger birth weight.

BENCE VIOLA: And birth weight is one of the prime predictors of infant survival. Small babies are much less likely to survive, especially if you don't have good medical care. And so this has been selected for really, really strongly. Generally, Asian populations carry about 0.1% Denisovan ancestry. So, only one-thousandth of their genome comes from Denisovans.

BENCE VIOLA: But in this one place, in this gene, in Tibetans, 80% of Tibetans carry

the Denisovan allele, so it's been selected for extremely strongly. And what is funny is that this gene has been known before, but people didn't realize it came from Denisovans. It was like the best example. It was always said this is the strongest selection pressure in humans, is this altitude adaptation in Tibetans. And of course, it's an adaptation, it's not that they adapted directly. They picked up this gene from the Denisovans.

HOST; This was kind of puzzling because Tibet is more than 1,200 miles from Denisova cave where the only fossil evidence of Denisovans had been found. Until just a few months ago when another astounding discovery was announced.

BENCE VIOLA: The jaw was discovered by a team led by Fahu Chen, Jean-Jacques Hublin, and Frido Welker. The fascinating thing is this jaw was actually found in the 1980s by a Buddhist monk who went to pray in this cave and sat on the jaw and picked it up and brought it back to his monastery. And it got absolutely no attention until this team started more detailed investigations.

HOST: They weren't able to get DNA from the jaw but thanks to a technique developed in part with funding from The Leakey Foundation, they managed to extract some proteins from the collagen in the bone and they found that the jaw seemed to be from a Denisovan.

BENCE VIOLA: It's pretty robust with very large teeth, so it fits this general Denisovan morphotype of large funky teeth and a very big head as we know from the cranial fragments we have from Denisova cave but I wouldn't peg a facial reconstruction on this jaw. I think that would be a little premature.

HOST: There's much more to learn about our enigmatic Denisovan cousins. What did they look like? How did they live? For how long, and where? Did they make any of the tools or artifacts in Denisova Cave? How did they migrate across the planet? What was it like when they met other hominins along the way?

I asked Bence Viola if he could go back in time to Denisova Cave, - what would he like to see. He reminded me that I asked him the same question a few years ago at a symposium in Cleveland.

BENCE VIOLA: I very much hope you destroyed that because my answer at the time was I would go back to the Denisova cave, hit a Denisovan over the head, and I'd hide

him somewhere where I can find him because I want to have a skeleton. But maybe no, I would just like to go and see them and I'd love to know how these interactions between Neanderthals and Denisovans, and Neanderthals and modern humans, and Denisovans and modern humans happened. I'm really fascinated by this question. How did they perceive each other? Did they notice that this is somebody who's a different group? Did they just think the guys over the hill who are kind of ugly? Or did they just interact completely normally? I think it would be fascinating to really see that. Go and be there when Denny's parents met, kind of peep in on their first date. It would be fascinating. I don't think it's possible, but I'd love to know how these interactions happened.

HOST: Because it's clear these interactions happened - frequently enough so that the Denisovans live on in us today. A mystery in our very genes. Part of the story of where we all came from. And part of the evolutionary explanation for the way we are today. Including our behavior, our bodies, and our health.

Along with the trait for high altitude adaptation that came from the Denisovans. There are genes related to our immune response, pigmentation, our ability to digest certain kinds of fatty acids which scientists say come from our archaic relatives the Denisovans and the Neanderthals

BENCE VIOLA: Our past really strongly impacts our present as well. And I think, yes, you could say, "Oh, but you know, it doesn't really matter why." There's, for example, one of the genes linked to diabetes also supposedly comes from Neanderthals, and you could say, "Why does it matter for the person who has diabetes, whether this came from Neanderthals or not?" You could blame Neanderthals for it, but that's not very productive. We should much more worry about how we can solve this problem. But I think that understanding the evolutionary origins of these issues is definitely also helpful for solving them.

HOST: And so work continues today. Many teams of researchers are working to uncover more about the Denisovans, collaborating with Russian scientists who have been working for decades in Denisova Cave. It's clear that there is still much more of our story to be found there.

BENCE VIOLA: Of course I'm biased, but in my opinion, it's the most exciting area to work in because you have this unbelievable situation where you have, in the same site, different hominin species that, I wouldn't say coexisted, but visited the cave intermittently, and at least sometimes clearly met, because otherwise we wouldn't have

any hybrids. The only site we know that is like this is Denisova, and it's probably not just Neanderthals and Denisovans, but the very first modern humans were likely also there.

BENCE VIOLA: The main chamber is excavated, I'd say maybe a quarter or if it is excavateD. So there's lots of stuff to do there. And the south Gallery, which is where this cranial fragment comes from, and the first beautiful Denisovan molar come from, that is barely excavated. They did two square meters, and there's probably 20, 30 times as much left to do. My colleagues are focusing on that at the moment, and seem to be quite successful.

I'm waiting every day. What usually happens, if they find something, they take a picture on their mobile phone and send it to me, and they're like, "Is this human?" It's like, "Hmm, hard to tell. It's a very little piece, and it's a very bad photo taken with your mobile." But still, it's exciting waking up in the morning and having, "Oh, maybe it's another Neanderthals or Denisovan on my phone."

HOST: And it's likely that thanks to new methods we'll find other secret histories in other tiny bones just waiting to be discovered.

BENCE VIOLA: I think probably the most important message of the Denisova story is that no fossil is unimportant. Even the tiniest fragment that seems completely useless, like a fragment of a finger bone, can open up a completely new world of human evolution to us.

END [MUSIC]

HOST: Thanks to Bence Viola and Viviane Slon for sharing their work. There's a link in your shownotes to more information about them and their research. Dr. Viola also wants to give a shoutout to his colleagues, including Anatoly Derevyanko over more than 40 years has excavated countless sites in Siberia, in Mongolia, in Uzbekistan, in Kazakhstan. - and Michael Sunkov who now heads the excavations at Denisova.

I also want to thank Sergey Zelensky who provided the sounds of Denisova cave and the recording of the press conference there.

You can learn more about Leakey Foundation grantee Frido Welker's work on ancient proteins on our blog.

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This season of Origin Stories was made possible by support from Dixon Long, Camilla Smith, Jeanne Newman, and donors like you!

This episode was produced by me. Our editor is Julia Barton. Our theme music is by Henry Nagle. Additional music in this episode comes from Blue Dot Sessions and Lee Rosevere.

We'll be back next month with a brand new episode.

Thanks for listening.