Transcript

Speaker 1: You're tuned in to 90.7 FM, k a l x Berkeley. My name is Tesla Munson and this is the graduates, the interview talk show where we speak with UC Berkeley graduate students about their work here on campus and around the world today. I'm joined by vertebrate paleontologist lives for air from the Department of integrative biology. Hello, welcome. And a, you actually just got back from an exciting trip in Berlin.

Speaker 2: Yes, I went to the society of Vertebrate Paleontology meeting. It was there [inaudible] it was just lucky enough that it was in Berlin, which is pretty awesome. Yeah. [00:00:30] And you presented something and even I did, yes. And uh, as I mentioned before, it happened to continue to carry around that presentation poster with me.

Speaker 1: Nice. You never know when you might have an opportunity to throw it up and teach some people about lizards.

Speaker 2: Yeah. Somebody who's like, what's science like? Well, I just happened to have this in my purse. I'm ready. Perfect. And you do study lizards, right? I do. Yes. I call myself a vertebrate paleontology list and I'm methods II. But, uh, I just happen to focus on monitor lizards for most of my research. Yes.

Speaker 1: Okay. And we'll get into all of that. So vertebrate [00:01:00] paleontology, can you just break that phrase down for us a little bit?

Speaker 2: Sure. Um, most people have heard paleontology, you know, the study of past life and I just focus on vertebrates, so things with the vertebral column and the past. And so they're invertebrate plantologist intelligists and there are people who study microfossils too, but I'm in the vertebrate realm. So like things with bones. Exactly. Yeah. Nice. Okay. Let's go back to the beginning. You, what's your Undergrad degree in? It's actually in geology, but I happened to go to university where I [00:01:30] could declare a specialization and I declared Paleo biology. So I did take a lot of paleontology classes and some bio classes also. And you did field work as well? I did, yeah. As a geology major we had to do field camp and so I was able to do a couple of field trips. They're focused on Paleo fieldwork as opposed to just like, here's some cool rocks we can talk about.

Speaker 2: But a few of the summers and undergrads who I volunteered for a few field programs as well. Can you tell us about them? Are they interesting? Are sure. Yeah. Um, I actually contacted [00:02:00] the Museum of the Rockies at one point there, one of the big field programs that a lot of people in Paleo happened to know about. And when I was just searching things online, you know, googling fieldwork, where do I do? Um, they popped up and saw, I contacted them and it was in Montana and that's where there are a lot of dinosaur bones. And so the first real thing I found in my own actually happened to be

part of a triceratops. And like every kid who's obsessed with dinosaurs would like want that as part of something they did in their life. And so I remember after I did that, I was like, I'm in the right place and I'm in the right [00:02:30] field.

Speaker 2: This is what I want to be doing. Um, but then we'll also, when I came here and started my graduate degree, my advisor, Kevin Padian, happens to do a lot of fieldwork also in Ghost ranch, New Mexico. And so I had gone there a couple of summers with the crew in him and that has tons of material of different, you know, different type of early rough towel guys and things. And so that was kind of fun to do. That's like with a larger crew and I don't think I ever found anything new there. But just sitting around digging up bones is a pretty [00:03:00] awesome way to spend a summer. Yeah, I know. So, which part of the triceratops was it? Was it like a little toe or something? Actually, yeah, most people always asked to, um, it's called the Epi parietal, which, you know, everyone knows the chick frill that they have.

Speaker 2: And so they have little bones at the end of their frill that make little bumps and it's one of those bones, uh, which was pretty cool to find. I had no idea what it was. It just looks like a triangle thing. Uh, so I remember holding it for a while until someone told me and then I was like, okay, good. No, I could tell people like, Jackpot. Yeah. Nice. And so the New Mexico [00:03:30] side was also dinosaurs, so actually, yeah, that is a little bit earlier material than what was in the Montana stuff. Um, and so that was kind of like you get groups that are there in early dinosaur ones and also a lot of reptiles that lead to other art, we call them arc or line kind of guys. So the crocs and things like that. So a lot of really different things there.

Speaker 2: Uh, since that's not my main focus, I don't know everything that's there. But, uh, it's, you have one field site that's early in dinosaur time and then I did Montana, which was later on, so 90 million years [00:04:00] later, you know, things like that. So was it a natural transition from dinosaurs to reptiles or how did that happen? Actually it was pretty natural when I was an Undergrad. I always assumed I was going to work on dinosaurs. That's what got me interested in paleontology as a kid. And I had done a undergraduate project on a dinosaur and then I kind of started to learn more about planetology and realized that there was so many other things out there besides dinosaurs as I hope people know. So then I started playing around with ideas of different side [00:04:30] projects and then I ended up having to take these classes on, on reptiles and mon reptiles here.

Speaker 2: And that's when I learned about monitor lizards and other groups. And I said, okay, I think that they're good to help me out for what I want to work on a little bit more. So just kind of just naturally came by playing around with different types of projects and ideas. So what is a monitor lizard? Um, so most people know Komodo dragon as like the most popular monitor lizard just cause it gets so large. But yeah, they're in the family veranda. Dave of people are interested [00:05:00] in that and then yeah, they're just, they pretty look like a typical lizard. How you'd recognize them. Uh, there are probably

over 70 species of them today, but when you see them, you could, you could recognize them as being monitored or lizard. They have that look, this long neck, this really long gate kind of face. And I got interested in them because since they're also, we call it conservative morphologically that they all look like that.

Speaker 2: Um, but they're very diverse in some areas. I wondered, okay, what is it about this group that even though they have this distinct look and body plan that works [00:05:30] for them, they could still get pretty diverse and, and how does that look in the fossil record? And so that was the kind of questions I was interested in possibly be dinosaurs, but uh, with monitor lizards, I thought I could bring in a modern component to compare with the fossil record and that's kind of a cool direction. Paleo was going. And so I ended up going that way instead. I know what part of the world do these live in? Are they all like in one part of the world they spread out 70 species? That's quite a few. Riyadh is. So today they're only, and a lot of the southern continents. And so we find them in Africa, [00:06:00] in southern Asia, um, all the way down to Australia.

Speaker 2: But we find fossils of them in North America, in Europe and in northern Asia too. Um, so that's kind of another interesting question as is, uh, like why are they now own southern continents? Where did they originate? And those are some of the things that people look at. Um, but their diversity today is, is pretty cool too. So you know, as I mentioned, there's probably over 70 species, although people are always debating that stuff, but they're really low diversity in Africa and Africa is huge, which is pretty interesting that, you [00:06:30] know, you only maybe have five or six species possibly there, whereas you have over 30 of them in Australia. And then who knows how many in southern Asia as well. So like what is it about this group that they did really well and Australia and why is it that they have this low diversity in Africa and like with the patterns that might affect that diversity. So that's kind of another thing that got me interested in looking at this group, at least for the modern species as well.

Speaker 1: So I have this picture in my mind of the lizard from [00:07:00] the adventures down under or uh, that Disney movie with the mice in Australia and there's a big nasty lizard. I think it's probably a modern [inaudible]. Yeah. But yeah. Okay. Seen that movie in a while. But now I have to watch it cause probably what it is. Yeah, it's like a really low to the ground beefy lizard with a big head and [inaudible]

Speaker 2: it's totally a veranda then if that's the case. Yeah.

Speaker 1: Okay, cool. Yeah, I'll, I can check that out. Um, so you mentioned that you find them in the fossil record, they're more in the northern continents, [00:07:30] but now you only find them in the, in the southern ones.

Speaker 2: Yes. It's just interesting that, that we had, we see things of them like in North America too. It's not exactly within our group. There are guys who are closely related to [inaudible] in the fossil record of them. So when I'm talking about for branded fossils, I

also made friends and friends and older family is kind of what I'm relating to. But the genus verandas which is, you know, all the, all the modern guys, um, they're, they're hard to identify that to exactly to the genus. So, um, we don't know exactly where they would have Virginia it [00:08:00] or how I would have gone or how all the fossil things might directly be related to them. But you know, when you see it a fossil, you know, that they're, they have enough of the characteristics that were like, okay, we know that they're related to this group, whether they're exactly in it or just a cousin of them. That's usually what people end up like debating on. But,

Speaker 1: so you mentioned a few, the characteristics like the, I think that thick neck and the long gate face are the, is that pretty much it or are there others?

Speaker 2: Um, uh, for people who are really interested in lizard stuff, one of the main things they have is they have, uh, on their [00:08:30] vertebrae, they have this really compressed portion of the Centrum or the center part of the vertebrae. So when people see that in the fossil record and you're like, okay, this is a monitor lizard or Molly's your family, we see that. But they do have like the really a long eight-ish neck for losers. Not all of them have necessarily the exactly long face, which is mostly what I study is actually, uh, the head shape for them and how that varies. Um, so even though they all look very similar, there's still some things do differ and do some interesting patterns and morphological changes on their face, but [00:09:00] they have really long tails there. Like you said before, actually they're really beefy. That's another thing. They're, they're pretty beefy kind of guys, but they're like this a long gate lasered and some of them get, like I said, like really large and some of them are really tiny. Like you're super cute, you know, size of the palm of your hands. And you find those in Australia stuff too. So they just do a lot of things with their size, if anything stuff too.

Speaker 1: So why do they all share these characteristics? Is it just a, because they have common ancestry or do you think there's some sort of [00:09:30] function to these characteristics?

Speaker 2: The first monitor lizard and you know, the ancestor that led to this group of guys, it just seemed to work in having this morphology palliate allow them to do a lot of different things and everything that they wanted or could do. I'm so just why mess with what ends up working for you? And so this allows them to just have really broad ecologies, which is another cool thing about monitor lizards. I mean, most of them as people know Komodo Dragon, you have these large carnivore guys. Um, but some of them even ended up going for givers, which means they're eating fruit. So [00:10:00] they're living in trees and feeding on that. The smaller ones we'll eat, we'll eat tiny things. The larger ones will eat larger things that they can get to. And they also live, some of them live in more desert regions. Some of them live near the coast near water, like on. So the Nile Monitor is people know that they've, you know, an Africa and it's near the river there and stuff. So they live in a lot of different places, different kinds of habitats and do a lot

of things. And so it just seems that their morphology worked to do a lot of these. So just why change it

Speaker 1: if you're just tuning in, you're listening to 90.7 FM [00:10:30] KLX Berkeley. We're in the middle of an episode of the graduates here on Calex. My name is Tesla Monson. Today I'm joined by vertebrate paleontologist Liz Frere talking about fossil lizards and living lizards, monitor lizards, Komodo dragons even. Why did they call them dragons? Do you know? Is there just that ferocious,

Speaker 2: that's what it is. They're so big and scary and like what other thing can you compare it to then the one of the largest mythological reptile thing that you know could attack you.

Speaker 1: Very nice. Yeah. [00:11:00] So what are some of the ways that you look at this? You mentioned like head shape, uh, and differences, how do you go about examining that?

Speaker 2: Yeah. Um, so for my research, as I mentioned before, I'm really interested in, you know, the, the, the head shape as I said, but also how it relates to diversity. How so? Um, what I tell people is I study diversity and disparity and modern lizards. And by disparity I just mean how much more Falaji skull shape, how much does it differ? So how much changes in shape across these guys do we see? And, um, I [00:11:30] focused on the head for that. And by diversity, the things I look at, um, when I count as diversity or just count. So how many of the guys are there? But I also look at something we call phylogenetic diversity, which, um, you know, it's just a fancy term for just saying, I'm looking at how, how closely related are the guys who are around there are. Um, and so it's biologically being their evolutionary history.

Speaker 2: So the way that I measure disparity or the morphological changes is a technique called geometric morphometrics. So there are different things you can do. People [00:12:00] can just do direct measurements, like how long is this skull here will, how big is this thing on here? But with a g alcohol at GM from now on is a shorter term for geometric morphometrics. It's an interesting technique you can do to quantify, just put numbers on a shape by putting a whole bunch of points on the skull. So usually I do it two dimensionally, meaning I just take photos and I'll put points on there and I'll compare how all those points across those photos might compare to one another or shift. So the programs will just computate that for me. [00:12:30] And then, and then that's how I get a nice number to quantify the shape for me. And then I can do a whole bunch of statistics on that.

Speaker 2: So how does the quantification of all these guys who live in this region of shape relate to the guys who live in this region or in this time period relate to guys to in this time period? Um, so that's kind of why I use morphometrics and for diversity. I mean a lot of that is has been done for at least counts. But, um, there's been a lot of research on their evolutionary histories already. And so we have the evolutionary trees and I play around with those to look at how the [00:13:00] relationships of the guys who live in different

regions relate to how much skull shape differs in those different regions. How, how does size play into this? I mean are they, you mentioned small ones, big ones. So the nice thing about geometric morphometrics is it that it removes a size component and so it doesn't matter how big they are because what it'll do is align the photos and just look at shaped directly every move size, although size is really interesting.

Speaker 2: So it's something I can look at with the data after the fact. And with monitor lizards, it's interesting because as I mentioned [00:13:30] previously in Africa, they have very low diversity but the guys don't different size as much as they do in places like Australia where there's really high diversity and you have the tiny guys who are, you know, size of palm of your hands. And then you have the really large ones too who you know can get two meters in length. And it's interesting to look at how size and shape my compare in those regions and that come by. That factor into why diversity might be different. Can you spill the beans on it? Is it more like related to how [00:14:00] they're related to each other or does it seem to be some environmental effect? So actually it, I, I think that there's a little bit more to it than like some of the, you know, most people will say if you have a high diversity you'll have high morphological disparity or like, so I expected to say, okay, there's going to be a lot of variation in skull shape in Australia for example, where there's a lot of them and not so much in Africa.

Speaker 2: But uh, I guess I could spill the beans for this part of my research. I found that it's actually not the case. And so you have an Africa [00:14:30] where you have, you know, just very low diversity. That's where they have the most differences in skull shape. And if you actually just look up pictures of these guys, you know, Google, you know, monitors and Africa, they do have these really weird skulls. Some are really broad and wide. Some are uh, more of the long aide and some had these weird bumps in their nose. And I just think that, uh, in Africa they also don't overlap too much where they all live. And so they're just really kind of separating things a lot more than I think that in Australia where the small ones in the large ones can live alongside each other a little bit [00:15:00] more cause they're not competing as much.

Speaker 2: I mean, you're a small guy, you're not eating the same things that the huge guy is. You're eating what you can. And so, um, that might factor into just why we have differences in like how much shape variation they have. You convinced me that for sure. Oh yeah. Okay, good. So where do you get these specimens? I mean, you're not just going out in like catching live ones, right? Or are they in museums or where do you find them? Yeah, luckily my research, since I'm focusing on the skull, I get to just mostly go to museums. If I was studying their ecology, [00:15:30] you're looking at them alive today, I would have to do a good portion of field work, which is kind of, you know, it's, it's a lot of time that you'd have to put into trying to find these guys and doing that.

Speaker 2: Um, but I ended up, most of my time is going to museums and photographing specimens to do the morphometric, the gem analysis I mentioned before. So I've, uh, traveled to museums here in the states. Smithsonian American Museum, actually the museum a

part of here, the Museum of Scientology at Berkeley has a lot of skulls to as well as the Museum of vertebrate zoology. Um, so yeah, last place in the states [00:16:00] and I've actually got a chance to go to Australia multiple times. So I went to Perth and I went to Sydney in the museums there just because, you know, if I want Australian specimens, they tend to have large number of them. And, uh, in the states here, we just have great collections stuff too. So, yeah, I get spent a lot of time going there and sitting in dark rooms with the camera photographing skulls. But I think the outcome is really interesting from doing all that.

Speaker 2: Yeah, no, that's really cool. I guess, uh, I think a here in the United States, people don't always realize that museums are not just about exhibits, [00:16:30] but that they actually have like collections back there. But obviously that's where you're getting most of your data from. Yeah. You know, so I, it's actually really interesting going to these museums. You have to walk through the public exhibits and in see everyone there and like, you know, the cool stuff's out there and stuff and uh, then you go to the back and the research areas, which many museums, you know, to have that because researchers are going, they're traveling and it's just way more stuff than people probably realize are there. And I feel lucky having gone to science, I get to see that. Um, so for other people might be like, this is kind of [00:17:00] boring stuff in drawers, but I'm like, there are thousands of millions of specimens here that can be studied.

Speaker 2: And people who could do research on. So think museums are really important, not only for just sharing science with the public, but also for us researchers to have access to so many different things that we can do and specimens and stuff. And you're definitely interested in sharing science with the public. Right? I know you're involved in a lot of outreach projects. Yeah. Um, I actually, I'm a little obsessed with outreach. Ah, I love it. So I'm part of multiple programs that allow me to, you know, go into classrooms [00:17:30] and talk about what kind of research people are doing here. But also I think that science should be shared with the public. People can see what's being done and also the kind of science that's done. And so, you know, if maybe you were interested in, in going into research and you didn't know if people did that or people would be interested in it, you can see that there's such a variation of things to do and people have done.

Speaker 2: And Yeah. And I think that, uh, for the classrooms and in research aspects, I think, um, teaching students what kind of scientist's done behind the scenes that's making the stuff that they're seeing in their textbooks, [00:18:00] it's cool to actually see science being done as opposed to telling, just told the results of it I think are really important. Um, so what are some of these programs? Do they have names? I know, yeah. Yeah. So the main one I'm part of right now actually is bay area scientists and schools, which you know, is in the bay area here. And I actually learned about them my first year as a graduate student here at Berkeley from Milan bait who had volunteered for them. And so they're like a, an interesting volunteer based type of organization. There were graduate students

can create [00:18:30] an hour long lesson and then go into local schools here in the bay area and teach it to students.

Speaker 2: And so you put the lessons online and uh, teachers from different grade programs might, uh, look and say, okay, well I'm teaching this topic and so what are some things that are being done there? And see somebody has lesson relating to it and then we can go and teach it. And um, so I volunteered for that the first few, couple of years here and I loved it so much. I'm actually a fellow graduate student here, Jessie Aderholt. Um, she happens to have a ton of skulls that she's collected [00:19:00] throughout her like life. And we created a program, a lesson, I mean to look at variation in skulls and teeth and we, it was for second graders. So how do you look at a tooth of animal and could tell us what it ate? And then it was all modern stuff. And we're like guys paying intelligence.

Speaker 2: What we do is we look at what monitor animals do and then put it in the fossil records. So we can tell, okay, well how do we know what fossil animals do? Oh cause we look, compare it to some things that modern animals do. So we created this lesson and the students were just so excited about looking at these skulls and so excited about the kind of research [00:19:30] we did. And then, and also that they always have an image of what a scientist is. You know, this, this older man in the lab coat holding a beaker and he stuck in a Digi room with like a whole bunch of liquids bubbling around him and stuff. And to see these two, you know, like 20 something year old graduate student women come in with skulls and tell him that quote Paleo stuff. It was like, oh, okay, so anybody could do science if you're interested in it and you do it.

Speaker 2: And so once I started seeing their reaction and like that's how they, they got excited about things, I'm like, okay, I think outreach is [00:20:00] way more important than people might necessarily. Like, uh, I mean people love outreach and want to do it, but a, for me it was like more important for me than I might've thought originally. And so, uh, yeah, so, um, I became part of the steering committee for this program and um, we have a lot of events that we help out and volunteer for. So I've gone and I invited to give a talk. I like a four h fair and stuff before. And I just basically talk about as a, what do you do as a graduate student and like science and get kids excited about it and want to retain their interest to hope that they might continue being [00:20:30] into science in the future. So you're not an old white man. Oh No. For people who are listening. No, I'm not.

Speaker 3: So yeah, apparently other people can do science. So is that an issue in, in science today? Yeah, actually.

Speaker 2: Oh, this is another group. I'm part of a integrated biology women in science. Uh, the nice thing about being part of that group is I, um, always wanted to keep up to date with, you know, what the numbers are and yeah, it's, you know, we have a, a lack of women in different science fields and biology. Actually, [00:21:00] it's interesting being a bio department because I'm surrounded by about more women than I was and my geology department for example. So in some fields it's getting better that the people who are

representing the field there, but in somebody scientific fields. Yeah. We don't have very many women. And, uh, also, you know, uh, people from low economic backgrounds or minorities and stuff like that, they sometimes they don't get much access to being able to do science or all those other things. And so I got, I'm really interested in that, um, especially from my background.

Speaker 2: So I'm the first person in my family to have really [00:21:30] gone even through college and everything. And I'm from New York and things. And so I wasn't surrounded by science or anything like that. And then I realized how important it is, you know, from the beginning to let people know what scientists like and the interesting thing and, uh, and I think that some stuff like that will help get more variety, more diversity within our fields is catching them early on and then teaching them like, what, what do you need to do to be a scientist? And like, you know, it's, anybody can do it. It doesn't matter what your background is. So I think that that'd be part of these programs.

Speaker 1: [00:22:00] Okay. Well, uh, maybe I can ask you another tough one while we're doing tough ones and why, I mean, why should we want diversity in science? Is that w what do diverse people bring to science?

Speaker 2: I think that, um, people who are coming from different backgrounds and, you know, different educations, they might look at things differently. And so I think that increasing diversity not only is, you know, is needed, it's great from people like to just have representation there but also people from different backgrounds. Yeah. You know, we have, the Nice thing is actually, uh, [00:22:30] at this meeting I was at, uh, it's, it's nice to see Virta periodontology becoming more diverse and stuff and we have younger people from different backgrounds and they tend to look at things differently. You know, you have the versus young old. And I think that, uh, diversity will help not only just make science hit a broader audience and stuff, but also I think that it will help further science itself because people will be bringing in a lot of different perspectives they might've had before. There are many other things, but I think that that's like a really important proportion of that. And also as somebody you know who comes from like [00:23:00] a, who's lived in a diverse area and uh, and has a fairly diverse family, like it's nice to, uh, to be part of a group like this and stuff there.

Speaker 1: So what would you recommend for students like undergrads who are interested in getting into science and for people who are too old to go sit in on one of your bases lessons? What, what can students do to get involved?

Speaker 2: Actually the nice thing is I feel like, um, people don't realize that, you know, you yourself, you're, you can contact museums or places there and say, Hey, I'm really interested in this. Is it possible for anything to do? So [00:23:30] I'm one of those people that I, you know, I don't, I don't care. I'll, I'll ask him and then I'm like, okay, what is it going to hurt if I don't get that? Um, and so I actually love when I get emails from high schoolers or even when I was doing elementary schools, they're like, oh, can you show me this or can

I come here? And you know, most people in the field are really open to sharing this. And so even if you yourself, you're like, okay, well I don't know where to start looking, what books to get or I don't know what kind of programs that are for people or where I am.

Speaker 2: You can contact people and they will help and stuff. So one of my favorite examples is actually when I [00:24:00] was an Undergrad, there was one summer where I didn't know what to do, uh, at all. And I, one of those people that I, I always have to feel like I have something going on. And I emailed, um, different labs. Um, so I went to Undergrad at Bowling Green State University in Ohio and you know, there was the, wasn't that much around me Paleo wise. And so, um, I had heard about these different programs and I came across Dr. John Hutchinson, he's in the Royal Veterinary College in London. And by his research. And I was like, you know, I just wanna email him to see if it's [00:24:30] possible for people from just here or from out of place to, to go work with him there. And he was just so welcoming. He said, yeah, you know, I have a lot of stuff that Undergrad can do and if you can get funding or anything, I could help out a little bit here too.

Speaker 2: And you could just come by. And I went up there and I applied for some Undergrad, uh, just general research funds and I went up there and I did that. So even if you're, let's say an Undergrad and you don't know what major you want or what to do, you know, just emailing labs and working for them a little bit, people are pretty open to that because [00:25:00] they understand it. Uh, and even younger. And I know of know people who have volunteered at local museums who just went back and help pick fossils and they were like eight or nine years old and they were already doing Paleo because they contacted them and said, hey, can I just come and help? So I think that just being really open and being willing to ask and look for these things, like anybody can start doing science.

Speaker 1: Yeah, no, that's great to know. Anybody, they don't have to be an old white man even they know. Yeah. Well we're just about out of time here on the graduates. [00:25:30] Do you have any last words for the audience?

Speaker 2: So if people who are listening or anything like that, you know, if you're interested in getting into going into graduate school or getting into science and something's been holding you back or anything like that, I just just try it. That's, I think that's my, that's ended up what I tell people a lot of the time. And I think it's really important to hear, even though it just sounds so simple, just just kind of go for it. And there's nothing that you can lose. And just see when that's happening. Maybe you'll go into science, maybe you'll go into something else, but I, you wouldn't have lost anything I [00:26:00] think you would gain more than anything else.

Speaker 1: Well, thank you very much for that, Liz. Thank you for the invite. Yeah, no nuns. My pleasure. Absolutely. Uh, this has been another wonderful episode of the graduates here on KALX Berkeley 90.7 FM. Today I've been joined by vertebrae paleontologist Liz for

talking about her work with dinosaur fossils and Veran ids and you know, all sorts of lizards and techniques, geometric morphometric techniques for shape analysis, and of course, all her wonderful outreach here in [00:26:30] the bay area, science education with students. So again, thank you so much for coming on and talking about your work today. Very welcome. And we'll be back two weeks from today with another episode of the graduate's Tuesday mornings at 9:00 AM every other Tuesday morning, 9:00 AM here on Calix. My name is Tesla Munson and, uh, this has been the graduates. Stay tuned. You're listening to 90.7 FM, k a l ex Berkeley.