Dr. Titus: Welcome to Monumental Science – an informal look at scientific research that has happened in and around Grand Staircase Escalante National Monument over the last twenty-five years. I'm Dr. Alan Titus, Paleontologists for the Bureau of Land Management's Paria River District. Today we are joined by Dr. Joshua Lively, a noted expert on dinosaurs, turtles and other vertebrates from the cretaceous period, and we want to thank Dr. Lively for taking the time out to be here with us today. Welcome Dr. Lively.

Dr. Lively: Thank you so much Dr. Titus. I appreciate you having me on.

Dr. Titus: Yeah, it's a real pleasure. Of course, we have a long working relationship over the years. It's been great, and I'm glad to have the opportunity to sit down with you in a studio and kind of pick your brain about your research and about your interest in Grand Staircase.

Dr. Lively: Absolutely.

Dr. Titus: Just as an icebreaker, what's one of your outstanding memories from work in Grand Staircase? Is there a particular place that you enjoy or find special at a personal level to you?

Dr. Lively: You know, probably one of the most personal, one of the most special places to me personally and professionally is the Horse Mountain area of the Grand Staircase. It's important to me personally, because really, that's where I was trained as a vertebrate paleontologist. I had some experience in paleontology coming into grad school when I started at the University of Utah, but nothing like the program that Alan and the others working at Grand Staircase had. So, horse mountain and there were so many great sites in that general area and there were some of the first big dinosaur quarries that I got to work with. So that's so, you know, one reason why that's you know, really, a special place to me personally. Because yeah, I think about all the knowledge that I gained very early on in my career working out there and then. Yeah, from a professional standpoint, there are so many. Important fossils from that area. Gosh, you know what one of the one of my favorite memories I guess is, you know we were finishing up this one particular quarry. And it was a quarry and a group of us were hiking the last set of ribs out of that quarry. Actually, I call in *Hadrosaur* quarry but there was also a new *Ankylosaur*, multiple turtles, a crocodile, all sorts of stuff.

Dr. Titus: The Horse Mountain *Gryposaur* Site.

Dr. Lively: Horse Mountain *Gryposaur* Site, and we were hiking the last set of Ankylosaur ribs out of it. Got a little lost! We were we were being led out by Mike Getty, and at the time yeah, yeah for your listeners, the team prepared at the Utah Museum of Natural History.

Dr. Titus: And a legend I might add.

Dr. Lively: An absolute legend, and so we kind of got of course. The sun was starting to go down and I said Mike, maybe I should turn my GPS on, and so I did. We finally found our way to the road, and when we got to the road, we were kind of exhausted. The rest of the crew had been working at another locality. Mike said I have something to show you, and they had popped out a hadrosaur vertebra during during their excavations that day at that site. e hadn't tapped the bottom side of it, I turned it over and right there was a turtle skull. It was just pure luck, something they weren't expecting, and it turned out to be one of the two or three skulls that we have of this new species of turtle that I named the following years, so that was kind of a really neat memory close to Horse Mountain, you know, kind of my one of my and many of our special place in the Monument.

Dr. Titus: Yeah, I remember they called that the Getty Camp up there, that you guys were working out of.

Dr. Lively: Oh, for sure.

Dr. Titus: Yeah, well that's great. So why don't you give us a little background on yourself and tell us how you developed an interest in your research.

Dr. Lively: So, I'm originally from a small town just outside of Birmingham, Alabama. I went to Auburn University for my degree in geology and then got onto graduate school for my masters at the University of Utah. It was one of those right-place, right-time sort of things because you know the Kaiparowits project there in Grand Staircase was going full steam ahead. We had a lot of different sites we were working on, and I had always really been interested in the Cretaceous period because it was a time of such warm global temperatures. Actually, turns out to be a really neat analog for potential warming that we have coming in the present and in the future with the modern-day climate. As a geoscientist we can look back into the past and see how the planet has run these then climatic experiments if you want to call it, and so the Cretaceous is a really-cool time to understand periods of really warm global temperatures. And because Kaiparowits is one of the, uh, yeah, really over the last twenty years, has become the place to search for vertebrate fossils in the Cretaceous rocks in the western U.S.

It was very much the right place, right time for me to be started graduate school, and out of all the critters that folks were working on, and that folks were excavating from Grand Staircase and the Kaiparowits formation. There really hadn't been too much work on the turtles, definitely some great preliminary work that had been done by Howard Hutchison and Mike Knell, but there was still a lot of detailed stuff to where I could carve out my own master's project on this one group of freshwater turtles called Baenids, and even though that group of turtles are totally extinct after the dinosaurs go extinct their, really turtles throughout their evolutionary history have pretty much always been turtles.

Dr. Lively: Even though the Cretaceous ecosystems were very different, with these young massive dinosaurs walking around, there's still turtles and crocs, and you know, some of the

smaller animals that, in the grand scheme of things, are pretty similar to those that are living today.

Dr. Titus: Yea, the turtles had a winning strategy, didn't they?

Dr. Lively: Yea, yea – they hit on something over two-hundred million years ago and stuck with it. But yeah, so yeah, just within the monument within the Kaiparowits formation and Alan, you probably have some idea of the statistics, but I would guess for every dinosaur we find there's like ten, fifteen, twenty turtle fossils.

So, the sample size there is just tremendous. So, for a scientist to be able to work with a sample size like that, you can start to make, answer biological questions then when you have so many fossils of one group of critters.

Dr. Titus: And I know in rare cases, we even have exceptional preservation with soft tissue and clutches of eggs inside them and things like that, that will give you even more of an intimate look at the ecology and biology of these animals.

Dr. Lively: Absolutely.

Dr. Titus: So, what do you see as the role for national monuments in research?

Dr. Lively: Yeah that's, that's a really important question. You know when you think about a place like the Kaiparowits formation and the Kaiparowits plateau that preserves this fantastic sequence of Cretaceous rocks. Yeah, one of the best sequences of Cretaceous rocks in the western U S in one small region. A National Monument has, national monuments, then provide that protection then for this area, where ya know in other places that I'm working in Utah and now am a curator back out here in Utah working full time and there's other places on public lands, these are very much multi-use. Grand Staircase in and of itself is also very much a multi-use landscape but in places like the Book Cliffs or in the San Rafael Swell or in a lot of other places you know there are a lot, a lot of different folks that are using these public lands for a lot of different purposes.

In some cases, industry all over the place. So, a national monument then, where we have these really exceptional places like in Grand Staircase, where you have these geological and paleontological features that are preserved nowhere else on the planet, they do really important job of preserving and protecting these resources, providing a mechanism then for researchers like us to go in and to learn more about our planet's history, in a way that we may not have had that organization within a given area and say other parts of Utah, Colorado, wherever, but you know, a national monument provides that kind of focal point that mechanism to be able to work together multiple groups as teams to learn more and more about the these fossil ecosystems.

Dr. Lively: You know having folks like the Denver Museum, the Utah Museum, all these different groups working together, and the national monument, then providing really the protection, and in some cases, the funding needed to conduct these big, very remote expeditions. I don't think we would know as much as we do about this fossil ecosystem, were this not a national monument.

Dr. Titus: Huh, interesting. So, I'm going to steer this back to a personal perspective for your own work in the monument and maybe have you recall some of the more challenging situations or anecdotes or stories that you have as you reflect on your research there. So, do you remember any particularly harrowing episodes or logistical challenges that you had to face while working in the monument?

Dr. Lively: So

Dr. Titus: It is a. It is a remote area, so there are there are those things to consider when you're out there working.

Dr. Lively: Absolutely, I feel very fortunate that I was trained in vertebrate paleontology in Grand Staircase because if you can do paleontology in southern Utah, in some of the most remote places in Utah, you can go anywhere and then do paleontology.

Yes, since working in Grand Staircase I've gone all over the Western U.S., the Canadian Rockies, Peru and all of those field areas are absolute bush league compared to the logistical issues that we face in Grand Staircase.

You know you can, you know you, you drive on a Jeep trail – sometimes it's there. Sometimes it's washed out for ya know twenty, thirty miles and then you know, depending on where we are working, you hiked in several miles as well. You've got to figure out, ya' know if your out there for two weeks, then you've got to have all the food all the water, all of the equipment for your field crew, however many people, five, ten, twenty folks, so it's, it's a challenge. Working anywhere in the field is a challenge when you have inclement weather 'cause yeah, that's one thing that you cannot control for, all you can do is prepare for it. You can, you can spend all this time with preparation and get out to a field area and then just get monsoon after monsoon, day after day.

So yeah, I mean gosh, it's - it's hard to narrow down any one particularly harrowing instance.

Dr. Titus: Cause there were so many.

Dr. Lively: Yea, 'cause there was so many. Really, working in Grand Staircase, like I said, when there have been other issues throughout my career leading field projects and folks think all this is so bad, I'd say oh this is nothing. Let me tell you about this one time hiking this knife ridge out of the monument while lightning is hitting us on every side.

Dr. Lively: You know, those are the things that really help prepare students, like myself when I was working in the monument as a student, help prepare you for those challenges and adventures to come.

Dr. Titus: Yeah, if you don't need a heavy-helicopter to lift a three-thousand-pound block out of the remote back country, it's easy, right?

Dr. Lively: Absolutely. I'll tell you. I guess one of the logistical things that stands out to me, and ya know, cause yea it's a challenge to narrow it down, but you mentioned helicopters. I was helping out in 2015 with the Natural History Museum of Utah 's helicopter camp. This is while I was still a PhD student at Texas, and I think it was on the second to the last day. Someone in the group found *Parasaurolophus* skull. I think it might have been Scott.

Dr. Titus: It was.

Dr. Lively: Yeah, and you know this was of course something that was really important to Tyler, Tyler Birthisel.

Dr. Titus: Yea, it was a complete cranium, from what I recall.

Dr. Lively: What that?

Dr. Titus: I said, it was a complete cranium from what I recall.

Dr. Lively: Oh Yeah, and that's the thing. Very quickly after Scott discovered this thing, we realized, oh, this is totally complete from the bill all the way back to the very end of the crest, but we had two days to do it. So yeah, its kind of, and a couple of us were working some other sites, and it became an all-hands on deck sort of thing where alright, we've got two days, and hopefully not two nights to excavate this thing. So, we worked late into the evenings, had our headlamps to hike back to camp when it got too dark to work anymore.

So yeah, and sure enough we got the thing jacketed, flipped, capped, and ready to fly the next day.

Dr. Titus: Wow!

Dr. Lively: That was one of those things. So yeah, we found on say day one, we worked into that evening, worked all day - the entire field crew day two and yeah were hiking back with our headlamps after we had finished. That was one of those things where you need a very experienced team that can work together, and you know that that's one of the big things to you know, the teamwork amongst all of these different crews working in Grand Staircase

has been phenomenal over the years, and yeah, so seeing that thing fly out with a really neat and turned out to be way heavier than we estimated, it probably doubled, the double the weight that we estimated when we flipped it.

So yeah, that was that was one of those things where we look back and say yeah, we did that!

Dr. Titus: Yeah, I know. You don't know what you're capable of until you're presented with situations like that and then you're amazed afterward. Like wow! We did that!

Dr. Lively: Absolutely!

Dr. Titus: So how many new taxa or species have you named from Grand Staircase now?

Dr. Lively: Well, so far three. So, I've named two new species of this genus of turtle, called during *Neurankylus – Neurankylus utahensis* and *Neurankylus hutchisoni.* One has kind of more of a streamlined shell like a lot of other river turtles. The other had this highly domed shell, that makes it look a lot like a Galapagos tortoise.

But that was pretty rare, we have one really nice specimen that was collected by Howard Hutchison back in, I think in the Eighties in Grand Staircase, so it's in Berkeley. There's another fragmentary specimen at the Natural History Museum of Utah that seems to have that dome shape to it as well, but we need to find more of those, I think. So those two were really neat, but the kind of the highlight for my turtle work so far from the monument, was an animal that I named called *Arvinachelys goldeni*.

So this was prepared by Jerry Golden at the Natural History Museum of Utah, and it was discovered from that Horse Mountain *Gryposaur* Quarry, we were talking about earlier.

Dr. Titus: Yup.

Dr. Lively: And you know, this was this thing was another kind of a different challenge to work on. You know, not very different from the logistical challenges you deal with in the fields. This was already fully prepared when I got into graduate school in 2010 and sat down and looked at it, and I knew my turtle anatomy. I wasn't a turtle expert or anything coming into grad school. I knew my rocks at that point, and I knew enough about vertebrate anatomy to say this turtle looks different. This is really weird! And the other thing with turtles is that if you ever see a turtle skull, they've got one bony opening in their skull for their nose, called out the external narial opening. This turtle had two, and that's totally different than every other turtle fossil in well over two hundred million years of turtle evolutionary history. Well, I think this is this bizarre. Just trying to figure out just basic anatomy of this thing was kind of a challenge.

Dr. Titus: Totally unique.

Dr. Lively: What's that?

Dr. Titus: Totally unique.

Dr. Lively: Totally, totally unique, and then actually the second fossil. The bonus turtle underneath the hadrosaur vertebrae that I told you about earlier on that Getty showed me, that ended up being a second individual of that new species.

Dr. Titus: Wow!

Dr. Lively: So yeah, I ended up naming that one *Arvinachelys*. The genus name *Arvinachelys* because it looked to me a lot like a like a pig snout, and *Chelys* is of course Latin for turtle. *Arvina* is the closest we can get to Latin for bacon.

I don't think they had actual bacon back then, but you know, it's basically our bacon turtle.

Dr. Titus: Salt pork. Yeah, that's great! Yeah, I'm sure there's some inside humor there too as well between you and Tyler.

Dr. Lively: Absolutely yeah, you know that that's one of the other challenges we face is getting all the bacon that we consume through our systems.

Dr. Titus: Yes!

Dr. Lively: While we're in the field. You know you have to have your protein.

Dr. Titus: To keep your insides well lubricated with pig oil.

Dr. Lively: Absolutely!

Dr. Titus: So, we're actually getting close to running out of time here, but I'd like to give you one last chance to sort of summarize what you think the take home messages from your research in the monument are, and what you think your contributions to Cretaceous research have been.

Dr. Lively: Absolutely, so mammalian? species kind of what typically gets attention and press releases and that kind of thing, but I feel like one of the more interesting things to me that I discovered through my research is just that even though we have these really warm global temperatures in the Cretaceous. The assumption is then that because of those warm temperatures, you then have a lower gradient in temperature from the equator to the poles, and that's definitely the case.

Dr. Lively: The temperature gradient from Florida to Alaska would have been much lower in the Cretaceous. You would have much warmer temperatures in the high Arctic during the Cretaceous than you do now. So, because of that assumption then. Well because of that reality, folks have made the assumption then those critters would be able to range over much broader areas than they do today.

Today, certain animals, especially cold-blooded animals, ectothermic animals like turtles - some species will have much more restricted range because they are adapted to one particular climatic regime, and so the idea was if you've got warmer temperatures and a lower temperature gradient during the Cretaceous, these animals should have been able to range over really broad geographic areas.

Turns out that's not the case with these turtles. Some did, you definitely had some that were regionally distributed from, say, Utah all the way down to Texas and Mexico.

But what's really interesting, we have a geological formation, the Dinosaur Park Formation up in Alberta that's contemporaneous with the Kaiparowits. It was deposited at the same time, and has actually been explored for fossils for yeah, I guess over a hundred years now, and up there they have three species of these baenid turtles. In the Kaiparowits, we have at least six. So, we have doubled the diversity. Even though the assumption has always been, well, you're going to have high diversity in these broad geographic ranges all over, all up and down western North America at the time.

Dr. Titus: Yeah.

Dr. Lively: But in in a fraction of the time searching for fossils in the Kaipaorwits, we have doubled the diversity. It's probably going to increase even more. In fact, probably some of the highest turtle diversity in the geologic record – I think after we've been searching the Kaiparowits for another twenty years we may have some of the highest diversity and turtles in geologic history.

Right now, that record is held Hell Creek Formation in Montana. You've got somewhere, you know more than twenty species of turtles living there. In the modern, you've got the Mobile-Tensaw Delta, where I'm from, Alabama, that has eighteen species of turtles living together in one system. The Kaiparowits, we're about to be up to at least seventeen, and that's only twenty years into a really, you know, focused, extensive prospecting in the Kaiparowits.

Dr. Titus: Yeah, that's actually quite amazing given that you've discovered, we've discovered new taxa in that time. I think you're right. That count will go higher.

Dr. Lively: For sure. So yeah, so really being able to tell that broader biological story, I feel like is one of my contributions to research in the Cretaceous here. You know, showing that even though you've got warm global temperatures, you've got much higher diversity, just like you do today the further South you go, and a lot of these species of turtles aren't broadly distributed, they are restricted to either smaller regions or even individual river drainages.

Dr. Titus: Right.

Dr. Lively: Just like some of the turtles you see today, like the map turtles of the southeast.

Dr. Titus: Yeah, so more similar to what we see today than would have been presumed.

Dr. Lively: Absolutely, which I think underscores why working in the Cretaceous and working specifically in the Western U.S. And then Grand Staircase is really, can really be a great analog for understanding deep-time changes in our ecosystem and help us learn more about our planet today in the modern day.

You know, we may think of the Kaiparowits and these times in the Cretaceous as this alien planet with these massive dinosaurs walking around, but when you start looking at some of the other critters: the crocs, the turtles, all these other animals, invertebrates as well, it looks a lot more similar than you think.

Dr. Titus: Yeah, well, you know what John, Dr. Lively, it looks like we're out of time. I would like to again thank Dr. Lively for joining us today and I want to thank all of you for listening, and with that will sign out.

Dr. Lively: Alright, thank you so much for having me Dr. Titus. I appreciate it.

Dr. Titus: Alright, talk to you later. Bye.