Getting Curious with Jonathan Van Ness
& Dr. Julia Clarke

JVN [00:00:00] Welcome to Getting Curious. I'm Jonathan Van Ness and every week I sit down for a 40 minute conversation with a brilliant expert to learn all about something that makes me curious. And if you're curious about whether or not I can say expert, I can! On today's episode, I'm joined by Dr. Julia Clarke, the Wilson Professor of Paleontology at The University of Texas at Austin and a Fellow of the Royal Society of Biology, where I ask her: What was poppin' in prehistoric America? Welcome to "Getting Curious," this is Jonathan Van Ness. I'm so excited for this week's episode because, honey, I have been very curious lately about dinosaurs. And then I'm minding my own business and I meet Dr. Julia Clarke, who is a Wilson Professor of Paleontology at the University of Texas at Austin and you're a Fellow of the Royal Society of Biology.

JULIA CLARKE [00:00:54] That's correct.

JVN [00:00:56] So you are an expert in dinosaurs, and, and their history.

JULIA CLARKE [00:01:04] Yeah. So what I study is, I like to say I study how new behaviors and structures arise in deep time. And the group that I study that in is dinosaurs. And what I'm talking about is like, how did dinosaurs gain flight? How did they get feathers?

JVN [00:01:23] Wow. So-.

JULIA CLARKE [00:01:25] But yes, I study dinosaurs.

JVN [00:01:26] Yeah, so, when we got to Texas, I started, and I think it's not even just Texas. I think for a lot, a lot of my life, I've often wondered, like when I look around a place, like I wonder what this would have looked like before it was completely developed and there was like old school, like, stuff, you know, everywhere. So it's like 250 million years ago. What kind of animals were roaming the earth? I'm going to take a guess and then you tell me if I'm wrong. Was it like a gigantic single cell fucking like sea anemones or like gigantic manatees that were the size of like three buses or, or, or was it like only like sealife because there was like so much oceans 250 million years ago?

JULIA CLARKE [00:02:14] I love those suggestions. I mean, I'm personally a huge fan of manatees, but manatees are very recent.

JVN [00:02:22] Got it.

JULIA CLARKE [00:02:23] So no manatees are around. They don't evolve. They're not going to evolve for like at least another 200 million years.

JVN [00:02:28] Oh fuck.

JULIA CLARKE [00:02:28] From later. Giant sea anemones. So, sea anemones are, are really interesting. I don't know of any giant ones, but what we do have that's giant. And you can see here in Austin, actually, in our Texas Memorial Museum, is we had giant Salamander relatives. So these would be, like, over 6 feet long. The skull length is huge. And they're actually really cute looking, I think. But they're killers. They were predators, land predators, but they couldn't lay eggs away from the water. So that in that sense, they're amphibians.

JVN [00:03:04] How do we know that?

JULIA CLARKE [00:03:05] Well, from what they're related to and from the fact that they lack traits that all egg laying, you know, things that lay eggs away from water that we call ammonoids, they lack features to put them in that group. So that's how we would know that they haven't yet evolved that trait that we see later on in amniotes. It's if that makes any sense. But anyway, giant amphibians and sail-backed, you know, these things, like, sometimes if you buy like a fun pack of dinosaur or a plastic dinosaur things, there's one that has like a big sail.

JVN [00:03:37] Yes.

JULIA CLARKE [00:03:38] It's not a dinosaur. It's not, no.

JVN [00:03:42] It's not.

JULIA CLARKE [00:03:43] No.

JVN [00:03:43] But it's a four-legged, big, scaly creature.

JULIA CLARKE [00:03:46] Yeah. It has a huge, huge sail on the back. And it's like walking on four legs.

JVN [00:03:50] Yeah, we definitely saw those in "The Land Before Time."

JULIA CLARKE [00:03:52] Yes.

JVN [00:03:54] Which basically gives me like 40 percent of my dinosaur knowledge and then "Jurassic Park" gives me probably my other 60 percent.

JULIA CLARKE [00:04:00] So we'll have to circle back on the "Jurassic Park" thing, because we can, like, get into that. But these sail-back guys are not actually dinosaurs. Neither are those giant amphibians. The sail-back guys are more closely related to us.

JVN [00:04:15] No.

JULIA CLARKE [00:04:16] Yes. So we have these, these reptiles, like, the we, we call them reptiles, but they don't fit our, our current definition of reptiles. But they're essentially early precursors of mammals, which is what you and I are. But these mammals lacked hair. They were egg-laying. They were all egg-laying. And they had these huge fins. Anyway, they are going to go, basically, go extinct. And in this world, after that, after this dominated this landscape, dominated by the giant amphibians and these sail-back mammals, mammal relatives, you're going to see dinosaurs coming into that picture.

JVN [00:05:01] OK, really quick. Really quick.

JULIA CLARKE [00:05:03] Yeah.

JVN [00:05:04] The sail mammals.

JULIA CLARKE [00:05:05] Yes.

JVN [00:05:05] Did they, like, did they have, did they-?

JULIA CLARKE [00:05:07] Like Dimetrodon would be an example.

JVN [00:05:09] Did they like breast-feed or something? How do we know they're like mammal related?

JULIA CLARKE [00:05:13] So they share unique characteristics of, for example, the skull with mammals that they don't share with lizards or, or alligators or birds or any of our fossils that are parts of that group. So we know they're more closely related to mammals. In fact, that record is really good. It goes from the sail-back guys to these guys that look, they're often called Therapsids. They look, like, super kind of, like, like they're on steroids, real beefy guys that are around in the early part of the Triassic. And, you know, it's gonna be a long time until you get little mini mammals, you know, like the ones that survive the KPG extinction that are all basically no bigger than a, a beaver size. Those guys, their hair covered that, that suckled their young, etcetera. Those are much later, so younger than around 150 million.

JVN [00:06:08] OK. So what makes the 250 million years ago period record really good? That went from the sail-back guys to the more steroid beefy guys?

JULIA CLARKE [00:06:19] Well, in Texas, we have. So in the we-, in West Texas, we have the Permian Basin. And this has got extensive fossil deposits that give us insight into that period right after the mass extinction again.

JVN [00:06:33] Which is the KPG thing?

JULIA CLARKE [00:06:34] No, this is the one that, that starts off the age of dinosaurs, right around 250 million years ago.

JVN [00:06:41] What's that about?

JULIA CLARKE [00:06:42] So that's, that's the big one. OK? So that's the mass extinction event. We say that there are three to four mass extinction events that shaped dinosaur evolution. The first one is the one right around 250 million years ago. And that's like the big one. So that's the biggest mass extinction we know about in the history of life.

JVN [00:07:03] Is that a volcano-based one?

JULIA CLARKE [00:07:05] We think that that is a giant volcano-based one.

JVN [00:07:08] Got it.

JULIA CLARKE [00:07:09] And it, it really decimates both marine systems and land systems. And there's a huge turnover in diversity. And after that, it's not immediately, but after that, dinosaurs come on the scene. And they come on the scene in what I like to call an army of these more active bipedal Archosaurs, you know? Like Archosaurs are your crocs and your birds and your, all your extinct dinosaurs.

JVN [00:07:35] And they're two-footed?

JULIA CLARKE [00:07:36] Yes. Like us.

JVN [00:07:38] And like, so like T-Rex-y. And like, 'cause weren't they more on their hind legs like standing up?

JULIA CLARKE [00:07:43] Totally, T-Rex definitely two-legged. Living birds, all two-legged, in terms of two legs on the ground. But in these early Archosaurs they weren't all necessarily always upright on two legs, but a lot of them had the capability of, of switching to being more on their hind limbs. So during certain gaits. And they were predators, mostly, and, but I have to come back to the two other mass extinctions.

JVN [00:08:11] Yes.

JULIA CLARKE [00:08:11] One is going to, is basically right between the Triassic and Jurassic. And that one is going to lead to the dominance of dinosaurs in the landscape. All these other Archosaurs, you're going to kind of become less dominant. And dinosaurs are really, that's the beginning of the real age of dinosaurs. Where dinosaurs are dominating these terrestrial ecosystems or land ecosystems. And then the last one, last one of the past is the 66 million years ago. Everybody goes extinct except relatives of your chickens, your ducks, your ostriches, all the lineages we have today. And then, of course, the sixth mass extinction now that's, that's affecting our living dinosaurs.

JVN [00:08:55] So basically, 250 million, million years ago, there's a massive one that kind of gets dinosaurs, as we think of them, currently, like even a little bit on the scene. So prior to 250 million years ago in that mass extinction, is that just like the, the random ones in the water, like getting a little bigger and, because isn't, is it mostly water before that 250 million years ago one? And not as busy?

JULIA CLARKE [00:09:17] Yeah. I mean, things are starting to move on to land before the big mass extinction. So we have our first organ animals that can, like, lay eggs away from the water that are very, you know, right before that mass extinction. What happens is that the things that were dominating, yeah, maybe these giant amphibian dudes, they start dwindling out and the guys that can lay eggs away from the water, you know, really are taking off. All different line-, groups of them.

JVN [00:09:50] And then the big mass extinction and then comes back more like the sa-. No.

JULIA CLARKE [00:09:56] No. Yeah. It's like no, exactly. It's like reshuffling the deck. Like so certain things are favored by the environmental conditions or can make it through or are flexible enough to make it through the mass extinction. And those ecosystems are different. Those, the plants that live in those ecosystems are different, like, yeah.

JVN [00:10:15] So, in Texas. It's like the sail guys, le-.. So wait, the ark there's arka arkapods first.

JULIA CLARKE [00:10:21] Archosaurs.

JVN [00:10:22] Archosaurs first. Arkapod, I don't know where that came from. Archosaurs first. Then it starts to be the sail guys. And then the other people?

JULIA CLARKE [00:10:29] No, the sail guys are around and the big giant amphibian dudes. And then the Archosaurs, which are your Dino relatives and stuff. Those guys are next.

JVN [00:10:40] Oh, got it. OK. Cool, cool, cool. And so they're around like, so really quick on the mass-.

JULIA CLARKE [00:10:45] You want to focus on Texas or oh, yeah.

JVN [00:10:47] Oh, no. Yeah, I love that. I love Texas too. But like, but basically, like all these mass extinctions are like, basically, volcano, volcano, volcano events, except for the volcano, an asteroid, which was the most recent. And now we're, like, serving like human climate change realness, which is equally as detrimental.

JULIA CLARKE [00:11:01] Exactly.

JVN [00:11:02] But, so, Texas basically looks a million, or a million, 250 million years ago. It looks like, foresty? Deserty?

JULIA CLARKE [00:11:14] Man, you know,-.

JVN [00:11:15] Mars-ish?

JULIA CLARKE [00:11:17] No, no, definitely not Mars-ish. This would be pretty, a pretty rich. I think you would think of, like, a pretty wet ecosystem. Because you also still have those amphibian dudes. You know, I mean, it has, it's, it's relatively moist. Lots of vegetation. The big transformation in Texas during the age of dinosaurs, which is really striking, is later. And that's when an inland sea, will, will basically split North America in half. And that's later in the Mesozoic. But you're going to split the entire continent. So you're going to have dinosaurs of the East Coast and dinosaurs of the west, western U.S. And those dinosaurs are separated by a seaway that goes from like the Gulf of Mexico area, Texas, all the way up through Canada.

JVN [00:12:06] Oh.

JULIA CLARKE [00:12:07] So it's basically splitting the continent in half.

JVN [00:12:10] Is that an Ice Age thing?

JULIA CLARKE [00:12:11] No, it's not. It's a sea level thing, but it's not ice-related. It, it has to do more with, like, tectonics. You know, the position of the continents and things like that. So.

JVN [00:12:24] Where does the Ice Age come into play?

JULIA CLARKE [00:12:26] The Ice Age is really recent. So the Ice Ages that we think about with, like, mammoths and Mastodons and a lot of folks, like, think those are dinosaurs. You know, dinosaurs are cool, big prehistoric, but they're not dinosaurs. Those are mammals because they're covered in hair. And they, you know, they're closely related to elephants, that's-.

JVN [00:12:44] But that happened post 66 or?

JULIA CLARKE [00:12:45] Oh, totally, yeah. That's in the thousands of years scale.

JVN [00:12:49] And but was North America looking like North America by the Ice Age?

JULIA CLARKE [00:12:54] Yeah. I mean, that inland sea had retracted away, so it was no longer there. But you do have, like, massive transformations that happen with the Ice Ages. So this is on the thousands of years scale. And in those you have a giant ice sheet that's sitting, covering most of Canada. And, and then you're going to have all the drainages, the water that comes off that ice sheet. And that ice sheet actually depresses the whole continent. You know, it's so heavy. We're still rebounding from that ice no longer being here. So it's a very recent timescale, much after the extinction of the non-bird dinosaurs. Bird dinosaurs would be affected by that, but not, not anything like a T-Rex or a Stegosaurus or something.

JVN [00:13:42] So 250 years ago, things are kind of-.

JULIA CLARKE [00:13:44] 250 million.

JVN [00:13:45] That's right. I'm so sorry. Yes. Thank you. Yes. So 250 million years ago, Texas is, like, above water. Things are basically looking like now. But South America is still touching like Antarctica. Things are still like, like you're, I'm just kind of recapping where we've gone so far.

JULIA CLARKE [00:13:57] Yeah, yeah.

JVN [00:13:59] So that's how things are kind of looking. But then after the big 250 million like big one. At what point does the water thing happen? And is that part of a mass extinction where water kind of invoke, like spreads over the middle of North America?

JULIA CLARKE [00:14:13] Yeah, that's going to be later. So that's mostly Cretaceous. So that,-.

JVN [00:14:18] Is that 100 million years?

JULIA CLARKE [00:14:19] A little more. But yeah. Like it's, so it's around 120, 120 million. So I'm, you know, I'm not remembering when the first parts of that incursion occur, but the Cretaceous is actually named the Cretaceous, it references chalk and chalk forms, cha-, chalk is basically the little skeletons of unicellular life. And you know, like the White Cliffs of Dover in England are Cretaceous and they're white, white chalk. And that forms, that's why we call the Cretaceous the

Cretaceous. Because there were a lot of shallow seas where there was a high sea level stand and it covered all of Europe was an archipelago. North America was split in half by these shallow seas, as I said, in South America. You have a sea that extends into big portions of the Amazonian Basin. So you have a lot of these shallow seas where the little tiny microorganisms, where shells die and they make chalks.

JVN [00:15:26] Oh, my God. I cannot even get over that. I can't believe the White Cliffs of Dover are Cretaceous. I've literally seen those. I can't believe we're going to take a really quick break. We're going to be right back with more Dr. Clarke right after the break. Welcome back to "Getting Curious." This Jonathan Van Ness. I also have learned, and correct me if I'm wrong, but aren't fossil fuels mostly, like, fossils from gigantic ancient trees that we then, like, burn?

JULIA CLARKE [00:16:00] Yeah. So fossil fuels are dead life. They could be dead life. It's mostly unicellular in the oceans that died and accumulated in great layers. It could be trees. It could be, you know, plants on land that accumulate and are compressed and heated and a variety of things and become fuels that power our cars. And I like to remind, since I'm in a school with a lot of people who are oil and gas inter-, interested, I have in my office a picture, a painting of a dinosaur with a bunch of cars suckling on the dinosaur. Just to keep people reminded that this relationship with past life and what we power so much of our lives with.

JVN [00:16:44] How did these deposits come to, did they? A lot of them, I would imagine, would have happened in the mass extinction events themselves.

JULIA CLARKE [00:16:50] Not necessarily so over time. It's just like the nature of a setting. So if you are going to get a big accumulation of dead life, that can occur at various periods, for example, periods of time where you have a lot of life. Like. So not necessarily kind of a mass extinction event. It's more to do with the settings in which this dead life is going to accumulate and be rapidly buried. So not necessarily linked with, with mass extinctions, but mass extinctions have totally shaped the life we have today, including our dinosaur life today.

JVN [00:17:33] OK, so, ooh, why? How?

JULIA CLARKE [00:17:36] Well, because we had mass extinction around 66 million years ago. And all of the non-bird dinosaurs went extinct. But those that are related to species we have today survived. And those different groups of these dinosaurs that survived gave rise to all of the birds we have today. And those are, that's 10,000 species of living dinosaurs on earth today. So it's pretty striking in terms of like, well, we don't have things like T-Rex or we don't have birds with teeth, but we do have all of our chickens and penguins and ostriches and songbirds and all of these things that are living dinosaurs, So they are incredibly, dinosaurs are incredibly successful today, although I should say they're experiencing a bit of hardship, that's an understatement, in the sixth mass extinction, that one that is occurring right now.

JVN [00:18:39] So there has been five, and, and climate change is the six.

JULIA CLARKE [00:18:43] The, the idea is that the change that earth is undergoing is so, right now, is so rapid, it would fit the definitions we've had for a mass extinction in terms of how fast species are going extinct and how it's outpacing new species arising. So that's the premise of this sixth mass extinction that we're, that we think we're in right now. 06

JVN [00:19:06] So was the one 66 million years ago, was that the one that wiped out the dinosaurs, that all the non-bird dinosaurs?

JULIA CLARKE [00:19:11] Yes.

JVN [00:19:12] So that's the one with the whole comet in the Yucatan Peninsula. And like ash going around the earth.

JULIA CLARKE [00:19:18] Yes.

JVN [00:19:18] So is Pangaea not a thing at 66 million years ago or are we past Pangaea? And it's looking like North America, South America, and, does it look like how it is now?

JULIA CLARKE [00:19:27] It looks more like how it is now 66 million years ago. You still got some things that are, are like, for example, South America is still connected to Antarctica 66 million years ago. You have some other, you know, the continents don't look precisely the same shape. For example, in South America, there's a, a huge ocean where the Amazon is today. So things are still pretty different looking. But definitely Pangaea has basically broken up or almost entirely broken up by this time.

JVN [00:19:59] This is an extremely specific question.

JULIA CLARKE [00:20:00] Yes.

JVN [00:20:02] But it just came to my mind, what about Madagascar? Was that still, isn't Madagascar that, like, kind of rectangle that's attached to Africa?

JULIA CLARKE [00:20:09] Well, it's not attached, but it's super near it.

JVN [00:20:11] Yeah, that's what I meant. It's not attached but do you think those were attached 66 million years ago?

JULIA CLARKE [00:20:15] So actually, Madagascar splits off pretty darn early. So Madagascar is already on its own 66 million years ago.

JVN [00:20:23] Interest.

JULIA CLARKE [00:20:24] I know, but tot-, what's totally cool, is, is India, it has started this journey from Antarctica and it passes by Madagascar. And we don't know how much exchange there is as India voyages north to run into Asia. Right? So you can picture Madagascar is sitting there. Africa's over next to it. And India is on this giant journey from being part of Antarctica to coming up and then eventually contacting Asia, which is fascinating for, you know, what animals were on India that were going to end up contacting groups of animals that they had not previously encountered in, in Asia, for example.

JVN [00:21:08] Okay. So that's kind of going on, and Pangaea is like what? Like 200 million years ago or something? 500.

JULIA CLARKE [00:21:14] Plus.

JVN [00:21:15] 200 plus.

JULIA CLARKE [00:21:15] Yeah. Yeah. So Pangaea is assembled in, basically, the Paleozoic and that's going to end right around 250, 250 million years ago. And then Pangaea starts breaking up as we move into the age, the so-called age of dinosaurs, the Mesozoic. And that's from right around 250 to 66. So, you know, the continents are separating South America from India. And like all these things that we'd recognize today as present-day continents are kind of separating over the age of dinosaurs.

JVN [00:21:48] Wow.

JULIA CLARKE [00:21:49] Of non-avian dinosaurs.

JVN [00:21:50] So then we get to 66 million years ago, which is, and that's when I interrupted with a question. But so there's a big series of debate around like how long that extinction took place.

JULIA CLARKE [00:22:00] Well, I mean, you know, we've had remarkable insights in just the last year. I mean, in the last year, what, there have been at least three papers refining what we call the chronology or the dating of that mass extinction. And a lot of new insights have come from work that's actually been done at, in part by scientists at U.T., my colleagues, where they drilled into the crater itself and could actually get fine-scale, you know, when does life reappear in the crater? Unicellular life. And it turns out it's super rapid. So unicellular life is coming back into that crater. The crater of doom you know? Where the asteroid hit relatively quickly. And the question is, you know, parsing what happens on the order of days? What happens on the order of months? What happens on the order of years?

JVN [00:22:49] Yeah.

JULIA CLARKE [00:22:49] But like super, you know, fast in terms of how, how that impact of the crater is going to spread globally.

JVN [00:22:57] Okay. I have a question.

JULIA CLARKE [00:22:57] Yes.

JVN [00:22:58] So when that impact happens and what is, you know, Mexico now, like the Yucatan Peninsula, there were, there was probably not, because isn't that crater what makes Yucatan Peninsula? No? Where is that? Where is that crater?

JULIA CLARKE [00:23:13] So it's like, so you know what I like to think about, have you been to the Yucatan?

JVN [00:23:17] I've been, yeah, I think, I've been to Isla Mujeres and like Cancun, and like and like Tulum.

JULIA CLARKE [00:23:22] Did you ever go to a sacred cenote?

JVN [00:23:24] Yes.

JULIA CLARKE [00:23:24] Where you can like dive in and-.

JVN [00:23:26] Yes.

JULIA CLARKE [00:23:27] They're deep pits.

JVN [00:23:27] And so clear.

JULIA CLARKE [00:23:28] Okay. So the cenotes are on the outer crater wall so the on, the out. So those cenotes form on kind of the outer, outermost rim of the crater and rim is probably maybe not necessarily the right word, but those sinkholes formed because there was like loose ground up debris on land and those sinkholes form. And so you can think of that as you were on the outermost reaches of the crater impact. But a lot of that impact was right off land and it was in the sea between the Yucatan and, like, the Gulf of Mexico. So the crater itself is just mostly off land. It does have some like outer, you know, crater parts that are where the sacred cenote line is formed. But that is into these shallow waters. And we think that one of the reasons that that, that impact was so devastating is that it hit all these carbonates which are like shallow marine rocks. And the chemistry of those rocks maybe made that impacts particularly devastating in terms of what it threw up into the upper atmosphere and how it changed climate potentially relatively rapidly.

JVN [00:24:44] Oh, interesting.

JULIA CLARKE [00:24:45] After the impact. Yeah.

JVN [00:24:46] So that is basically what I was asking is like did it, I guess, like I was like, did, was it like land there and then like this big asteroid made it water? But no, it was like, it already, it had hit an ocean. It hit like ocean water anyway.

JULIA CLARKE [00:24:57] Yes.

JVN [00:24:57] Interesting. So do you think that it caused tsunamis or no? Do they know?

JULIA CLARKE [00:25:00] We know, we know it did cause tsunami.

JVN [00:25:02] It did?

JULIA CLARKE [00:25:02] Yeah.

JVN [00:25:03] Like big ass-. How do we know that?

JULIA CLARKE [00:25:05] Because in, actually, the edges of, like, the Caribbean and southern part of the US, there's tsunamiites, these are rock deposits that uniquely formed during, during tsunamis. And we have tsunami signatures in, in areas close to the actual impact. So these weren't that we know of global tsunamis, but they were tsunamiites that affected the region near where the crater was and they're very clear rock deposits indicating there were tsunamis. Yeah.

JVN [00:25:36] That is fascinating.

JULIA CLARKE [00:25:36] But we're causing as much impact in the environment in very different ways in our, in our human modified environment that it's a different kind of impact. But we think this is on the scale of what, what changed, caused mass extinctions in the past because of the extinction rates we see for, for living species and the extent of human modified environments today. So we don't have those giant volcanoes, but we have us.

JVN [00:26:04] Well, maybe the ads that were about to listen to will help turn that climate change frown upside down? So we're gonna take a really quick break. We'll be right back with more. Dr. Julia Clarke after the break. So, welcome back to Getting Curious, this is Jonathan Van Ness. OK, so, generally, like, what do we know about how dinosaurs looked, sounded, like, I think, you know, I was saying earlier, like "The Land Before Time" and "Jurassic Park" make up a lot of my, my working understanding of dinosaurs. So how much do we, how much is Hollywood gotten to correct?

JULIA CLARKE [00:26:44] Well, it depends on the movie. Which ones? Like the original "Jurassic Park"s movies or the "Jurassic World" series, the more recent one, because there's a, there's a pretty big difference in how accurate those movies are. So the first "Jurassic Park" movie really tried to get the, the new science right. You know, it showed the dinosaurs as more birdlike. They like are, you know, there, there are tiny dinosaurs that act in this very bird like way. And it really incorporated the science that, you know, said birds are living dinosaurs and that had actually been around for a long time. When you get to the most recent movies, the dinosaurs slobber a lot and they really don't look like what we now know most dinosaurs would look like. And that's when I think we've kind of lost the trail. You know, they have one line in the new "Jurassic World" movie where they say, "Well, we know dinosaurs were mostly fuzzy or feather covered, but we, we chose not to make our new high bred dinosaur have that." Do you know what I'm saying?

JVN [00:27:57] Right.

JULIA CLARKE [00:27:58] And that's a cop-out, because I think you can make really scary dinosaurs if you want to do that, that are scientifically accurate. So, most dinosaurs, we have some evidence for like bristles or fuzz on a lot of our charismatic dinosaurs, like large tyrannosaurids with bristle like structures on their body. And also, you know, maybe like legs that were more scaly.

JVN [00:28:24] And how do we know that? Like when you find a fossil that, like how do we know that there was like those structures on the sides?

JULIA CLARKE [00:28:30] Yeah. So, I mean, the big insights have come out of fossil deposits, mostly in northeastern China. And they actually are, they're in lake beds that, the lakes deepen quite rapidly and in sediment came in, very fine sediment really rapidly buried stuff and it preserves in really fine detail structures that are usually not preserved in the fossil record like filaments or feathers, etcetera. And so in the last about, you know, 20 to 30 years, we now have, like, small bodied tyrannosaurids that are covered in kind of bristle structures and large bodied tyrannosaurids with like bristle structures. And then we have small bodied, small things that are relatives of Triceratops that have bristles on the tail. But most of their body is skin.

JVN [00:29:23] Would a bristle look more like a porcupine sort of thing or?

JULIA CLARKE [00:29:26] Just think of, like, a really, like, a thick. It's not a hair. It's definitely not a hair. But you can think of a bristle like thick hair. So that would just that's the diameter that I'm talking about. It's not, they are not hairs. So our hairs and our, our fingernails, our, our hair is made out of alpha-keratin. But all the structures in reptiles are basically made out of beta-carotene, which has different properties. So these filaments are not hairs, but they would have looked kind of hair-like. And so a bristle is just, like, a super thick hair. And that's, that's where, how we use the term when we're not talking about dinosaurs.

JVN [00:30:08] And then these dinosaurs that have, like, so really-.

JULIA CLARKE [00:30:12] Not as rigid as a porcupine. A porcupine can stab you with those things. A bristle is more flexible or bendy. I was trying to think of a good way to say that. Yeah.

JVN [00:30:21] So is there really like any dinosaur that we would have that, that we grew up thinking or at least, you know, I'm 32, like, grew up in public schools, that, it's like. So was there really any dinosaur that was totally scaly in the way that we think of them now, or were they all having more bristles and or feathers?

JULIA CLARKE [00:30:37] So huge, you know, people debate this. I think, I'm going to give you my picture of it. We don't have any evidence yet of bristles in the-, if you think of the four-legged guys like the Sinclair Oil dinosaur, do you know what that dinosaur is? It's the sauropod dinosaurs. So these are the super big dinosaurs. They're quadrupedal.

JVN [00:31:01] The huge long necks?

JULIA CLARKE [00:31:02] Huge, long next, tiny heads.

JVN [00:31:03] Yes. Yes, Littlefoot.

JULIA CLARKE [00:31:04] Yes, Littlefoot. Exactly. So we don't have any evidence yet of sort of bristle structures in dinosaurs like that. So they seem to be scales.

JVN [00:31:13] What about the hard head ones like Sarah?

JULIA CLARKE [00:31:16] Sarah is part, is fairly closely related to Triceratops, and it, and we do have evidence of parts of that lineage having bristles. We don't have any evidence yet from that particular kind of dinosaur, but relatives of it. Yes.

JVN [00:31:32] And so probably in "Jurassic Park" and "Land Before Time" would, all of those dinosaurs probably not lived at the same time?

JULIA CLARKE [00:31:37] Oh, yeah, definitely they mashed up dinosaurs from different time periods for most of the movies. They're just putting ones from different time periods. I know. It's very confusing.

JVN [00:31:47] Son of a bitch. I wish they wouldn't have done that. That is very confusing.

JULIA CLARKE [00:31:51] Yes.

JVN [00:31:51] That is so rude. So I have a question. So how do you know that the, the, that the filaments or the structures that you see like, how do you like, how do you know that that wasn't, like, some other animal that fell on top of it?

JULIA CLARKE [00:32:05] Yeah. Well, it's a great question. I mean, when we first found the first one or two of these things, they were like, for example, the first time we saw these fuzzy structures and dinosaurs, they were, there were only a couple of specimens known. And so people thought maybe that dinosaur just, like, died on top of a plant that looked bristle shaped. But that's been refuted because we also find more examples of the same dinosaur with the same structures. And so it didn't keep falling on top of a plant. You know what I mean?

JVN [00:32:37] Over and over. Yeah.

JULIA CLARKE [00:32:38] Yeah. And, and you can look at the fine structure of these things and they're not plant-like. The other thing that's pretty cool is when we found feathers, and that was a big remarkable thing, is that in the dinosaurs most closely related to our birds today, we found all sorts of feathers. And we keep finding more. And so now, I would have to say, is probably in the thousands of specimens of things with true feathers from mostly these deposits in China. And those are in the dinosaurs that are, like, related to Velociraptor, related to Troodon, those things.

JVN [00:33:16] What did Troodon look like?

JULIA CLARKE [00:33:17] Well Troodon is a North American dinosaur. But Troodon's relatives' from these deposits in China. Oh, my God, they're so cool. They're like, they could fit on my lap. So they're, they're tiny and they've got all different kinds, like depending on the species of feathery arrays. So the one that I worked on, which was Caihong Juji, which is the Rainbow Dinosaur, it, it could fit on my lap and then have this fan tail and then a little tiny head that I think looks like a little mini vlas-, velociraptor's skull, and then short little wings that are fully feathered and then feathery legs as well. And then they're feathery all the way down to the tips of their, where they have their toe claws.

JVN [00:34:08] So we're talking, like, there is different dinosaurs, like small feathered ones and huge ones with feathers.

JULIA CLARKE [00:34:14] Yeah. Well, you know, huge animals generally, they have a problem with heat loss. So like an elephant has less hair than a mouse. Right? Because it, essentially, you could overheat as a super large mammal. So we anticipate that super large dinosaurs would be less likely to be covered in, in structures that would be insulating. So, you know, it was interesting to see bristles on the, on the skull and on parts of the body in this large T-Rex-sized dinosaur. But maybe those weren't dense and covering the whole body like hair. There were, like, bristles in parts of the body that could be used, you know, for show. But you would, you would hit issues of heat loss. So we don't know of any. Really large dinosaurs that are completely feather covered as of yet.

JVN [00:35:07] Now, what about-?

JULIA CLARKE [00:35:08] Extinct dinosaurs, I should say.

JVN [00:35:10] What about colors? Like is there any, like fossils that would give evidence to, like, a certain color of something?

JULIA CLARKE [00:35:17] Yeah. I mean, there were breakthroughs which were really cool in, in starting in around 2008 that showed that in these fossil feathers, in these, these lake deposits, mostly you could take a fossil feather, put it in a scanning electron microscope and you could see fine, tiny structures that are the same size and shape as the color conferring structures that are most common in living birds and mammals. And these are called, these little structures are called melanosomes. They're in your hair, they're in my hair, they're in bird feathers. They're in dinosaur feathers. So extinct dinosaur feathers as well, and the shape of these structures correlates with the color of the hair or the feathers. So, for example, in red-haired individuals, the little melanosomes tend to be round and in, in reddish-brown bird feathers, they tend to be round, but in black hair and black feathers, they tend to be longer and skinnier. So we could start finding these things and sample little tiny samples all over extinct dinosaurs that had feathers. And we could compare them to living birds and estimate the color patterns of extinct dinosaurs for the first time.

JVN [00:36:34] But that would have been like red, brown and black families, like?

JULIA CLARKE [00:36:37] And white because whites the absence of these structures in most, the simplest way to make white is the absence of these melanosome structures. So that was the first color maps that were, that, that were put forward. And then we found evidence of iridescence. So unique structures that these long, skinny melanosomes that are uniquely associated with shiny blacks, for example, shiny black feathers.

JVN [00:37:05] So then where do you think the most untapped or most like undiscovered fossil records could be that like we just aren't on to yet?

JULIA CLARKE [00:37:15] Well, I'm, I'm pretty excited about the work that we do in the si-, high southern latitudes. So Antarctica and southernmost Chile. I just got back last week from being down collaborating with Chilean paleontologists there, because you’ve got to go somewhere that hasn't been extensively studied. I mean, the truth is new fossils are coming from all over. You know, Europe, there are new fossil deposits being found in your backyard. If you have a backyard with rocks of the right age, you could find something new. So discoveries can be made anywhere. I'm, you know, I'm still, I think we got a lot of new stuff that's coming out from all over the world. So it's no one location. I still think these feathered dinosaurs are, have been incredibly important in changing our ideas about major ideas about what dinosaurs looked like.

JVN [00:38:12] So you're, and we're going to start to wrap up, my so apology, we have to have you back, because you're just incredibly fascinating. And I think also for me and I think for so many of our listeners, like, this is such a fascinating topic that we have to, like, get, like, a more general understanding of to even go into, like what your expertise is. But we have to, like I mean, all this has been your expertise, but like what you really, like, what you hone in on, because really what you study so much of is like, is like, feather, like, feather evolution in dinosaurs. Is that like?

JULIA CLARKE [00:38:41] Well, I, so I like to study like, OK. You know, we, think of it this way, we've had more than, you know, 4 billion years of Earth history. And throughout Earth history, new structures came on, new ways of behaviors, new features of the body came on the scene. That totally changed, you know, a group's interaction with its environment. So in the case of feathers, you get flight today enabled by feathers. Feathers arose for some other reason. And then they're co-opted to enable flight, which characterizes this amazing diversity of living dinosaurs today. So how did that happen? Right? So, but I also am super duper interested right now in the evolution of sound-making in dinosaurs, including living birds. And that's where we found the first fossil evidence of a fossilized vocal organ from the age of dinosaurs. So we've been doing this work to try to figure out, well, what, what, how would we approach the question of what did T-Rex sound like? And so that's kind of, that's another novel behavior, novel structure, slash behavior interaction that I want to study. I want to figure out how that, how that, those changes occurred and in deep time.

JVN [00:40:05] What was the vocal box attached to, like what kind of animal?

JULIA CLARKE [00:40:08] I mean, you're trying to wrap, wrap up right now, Jonathan. I could go, I could talk to you for an hour about this because, like, you and I are talking right now using our larynx or voice box. But birds have a unique vocal organ that sits. I like to say, well, it sits right behind the heart. So you can kind of remember that by thinking birds, living dinosaurs, sing from the heart, if you will, right behind the heart. So they have a vocal organ. That's where their windpipe branches into two parts and goes to the lungs. That's where they have muscles, they have vocal folds, and they don't make sound from their larynx. But if you think about what a larynx can do, human language is enabled by a larynx. So why did dinosaurs uniquely evolve a structure in a different part of their body that no other animal did? No other animal does this. Why did that happen? How did that happen? And how is that related to complex vocal communication in birds? Because birds haven't, like, think of a parrot, which can mimic human speech. Chimps and other primates cannot mimic human speech, but a parrot can mimic human speech.

JVN [00:41:22] Oh, and that’s, like-.

JULIA CLARKE [00:41:23] How does that happen?

JVN [00:41:24] And a parrot will be more similar, is that?

JULIA CLARKE [00:41:27] It's a living dinosaur.

JVN [00:41:28] Yes. So basically, dinosaurs could, would sound less like roar-y and maybe more bird-y. Birdish.

JULIA CLARKE [00:41:38] Yeah. Well, it's definitely less roar-y, because think about what your mouth does when you make a roar.

JVN [00:41:45] Raaa.

JULIA CLARKE [00:41:45] Right. OK. Dinosaurs have no lips. They don't have the mobile tongue that we have, which is shaping most of our sound making. So what you have is sounds that can be really menacing, if you think of crocodile sounds. Those are made with the larynx as well, or even some birds. So like ostriches, we could go to an ostrich farm right outside Austin here. And the males inflate their entire esophagus and make these boom calls. They're like, I can't, I can't really mimic it. Mmmm, mmmmm, mmmm.

JVN [00:42:22] Oh, yeah, yeah, yeah.

JULIA CLARKE [00:42:24] But if you imagine, something the size of a T-Rex doing something in this low frequency booming, that's equally scary.

JVN [00:42:31] Yeah.

JULIA CLARKE [00:42:32] It's just that we based a lot of our sounds for dinosaurs on lions and tigers and bears, which are not closely related to them. Roaring, that roar.

JVN [00:49:40] Yeah, OK. So as we come into home, last question, What do you think is the biggest misconceptions about, about your field? About how we understand dinosaurs, about paleontology, about all of it? What do you think is the biggest misconception?

JULIA CLARKE [00:42:55] Well, I think one big misconception is, like, it's all dudes that look like Indiana Jones. You know? I mean, when I was growing up, those were all my role-. I wanted to be an explorer, but there weren't very many models for, like, women explorers. So I think one misconception is it's all guys who wear vests with, like, a lot of pockets and have a lot of multi tools, you know? Or that you need to have a strong back, you know, to lift heavy things. I mean, the stuff I work on is tiny, like, I like tiny dinosaurs. So it's about your eyes. It's about recognizing things in the field, recognizing connections that may be, that anybody can do, you know? I mean, that anyone can, can do that, that kind of science with training. And paleontology is not just about finding new fossils. It's finding a way to think about new questions that take, that take, bring a new perspective to fossils. So that's what, I guess those are my big misconceptions, I think.

JVN [00:43:57] Thank you so much for your time. We have to have you back, if you will honor us with your presence again, I would love to have you back here. You're incredible.

JULIA CLARKE [00:44:02] It's been fun.

JVN [00:44:02] You're just amazing. Thank you so much. I really appreciate it, Dr. Julia Clarke. You'll find links to her work. You'll find all of her links in this episode of whatever you're listening to. And again, Dr. Julie Clarke, thank you so much for your time.

JULIA CLARKE [00:44:12] Thank you very much for having me.

JVN [00:44:18] You've been listening to Getting Curious with me, Jonathan Van Ness. My guest this week was Professor of Paleontology Julia Clarke. You'll find links to her work in the episode description of whatever you're listening to the show on. Our theme music is "Freak" by Quiñ - thanks to her for letting us use it. If you enjoyed our show, introduce a friend, honey, and show them how to subscribe. Yes! Follow us on Instagram & Twitter @CuriousWithJVN. Our socials are run and curated by Emily Bossak. Getting Curious is produced by me, Erica Getto, Julie Carrillo, Emily Bossak, Rae Ellis, Chelsea Jacobson, and Colin Anderson.