Video Transcript - What Tiny Fossils Explain about Big Dinosaur Ecosystems

Maggy Benson: When we imagine dinosaurs, we think big. But we need to look at the small details to understand the complete story. How can scientists reveal the world of dinosaurs [00:00:30] through tiny fossils? We'll find out today, when we talk with Paleontologist Matt Carrano. I forgot how much fun these can be.

Maggy Benson: [00:01:00] Hi. Welcome, everyone. Thanks for joining us for another episode of Live from Q?rius, Smithsonian Science How? So happy to have you here. Today, we have a very special guest. With us now is Curator of Dinosauria and paleontologist from the Smithsonian's National Museum of Natural History, Dr. Matthew Carrano. Matt, thank you so much for being here today.

Matthew Carrano: It's great to be here, thanks.

Maggy Benson: Matt, today you're gonna help us understand how you study microfossils to better [00:01:30] understand dinosaurs and the places that they lived in. But I think to kick off our show, we should start at the beginning.

Matthew Carrano: Fair enough.

Maggy Benson: With you telling us a little bit about what you do as a paleontologist here at the Smithsonian.

Matthew Carrano: Sure, sure. Well, I'm a paleontologist, so really, all that means is I study ancient life. I happen to study dinosaurs, but paleontologists can study plants or clams or whatever. And so I'm a curator, so I care for the collection. I study what we have in the museum and I go out and I get new fossils.

Maggy Benson: Sounds like a really cool job.

Matthew Carrano: It's a great [00:02:00] job. And of course, we're gonna talk about it today.

Maggy Benson: So before you tell us exactly how you study those dinosaurs, I think we should ask our viewers how they think you do that.

Matthew Carrano: Yeah.

Maggy Benson: What do you say?

Matthew Carrano: Yeah, I'd like to hear.

Maggy Benson: All right. Viewers, here's an opportunity to participate in a live poll to tell us what you're thinking. Tell us. Scientists study dinosaurs by: Assembling whole

skeletons? Comparing to living animals? Collecting fossil fragments? or Recreating ecosystems? Take a moment to think about it [00:02:30] and put your answer in the window that appears to the right of your video.

Maggy Benson: So I think a lot of people took a clue from our topic today.

Matthew Carrano: It seems like it.

Maggy Benson: And so most of the responses, we're at 63 percent, say that collecting fossil fragments is how you study dinosaurs. What do you say?

Matthew Carrano: That's a good answer. I think those people are right, [00:03:00] but I think it's a little bit of a trick question, because the other people are also right. So we do all these things in paleontology, and it's actually important to do all of them, because you'll learn different things by doing each of those different things.

Maggy Benson: And so has this always be the way that paleontologists have worked? Have they always done all of these things, or have they traditionally focused on just collecting fossils, maybe?

Matthew Carrano: A long time, I think, in the history of paleontology, really, collecting was the most important thing. And if you can imagine, 150, [00:03:30] 200 years ago, being the first people to find dinosaur fossils, you don't have any context. What are these things? So what you need is you need to find them. You need to find good fossils and put them together and understand what they are.

Matthew Carrano: And so for a long time, that's really what the focus was. In fact, when you go to museums today, you're seeing skeletons most of the time, that were collected probably more than a one hundred years ago.

Maggy Benson: And what do these whole skeletons tell us?

Matthew Carrano: They tell us, I think, the really straightforward thing, which is what does the animal [00:04:00] look like? But they tell us things in detail about the animal, as well, that record things about its history, its evolution, maybe what it ate, how it moved. But some of it is really just simple puzzle. What's this puzzle look like? If you're the first person to pull up a stegosaurus and you don't know what stegosaurus looks like, good luck. Until you find a skeleton, you're not gonna get it right. And most of the time, we got it wrong, in the beginning.

Maggy Benson: So one of those responses in the poll question was comparing fossils to living animals today. How has that revealed new information?

Matthew Carrano: [00:04:30] That's been important because as paleontology's moved along, we've gotten a little more biological in how we think about things. We want to know now about how the animals lived. We've got two ways of doing that, really. You

can look at things that are relatives of dinosaurs, and that would be crocodiles and birds. And they inherited certain shared features that we can study today.

Matthew Carrano: Or you can take a view and say, "Well, let's look at an animal that is similar, in the sense it's a big animal, like an elephant." So maybe there's something analogous about that that helps us understand dinosaurs.

Maggy Benson: [00:05:00] Very cool. So have the depictions of dinosaurs over time changed, as they were comparing them to different animals? Or maybe constructing those skeletons in different ways?

Matthew Carrano: Oh, yeah, it's great. If you can get a chance, you see the sort of history of dinosaur illustration. It really is like a window into how people were thinking it. So you can see. This is one of the oldest pictures of a dinosaur, from the 1850s. And you can tell they were looking at kangaroos. They had a two-legged animal. Well, okay, it's not a person. Kangaroos is a good model.

Matthew Carrano: But after a little [00:05:30] bit of study, they realized, "Well, these are really reptiles." And people got into a little bit of a zone where they thought, "Well, they should look like reptiles," so now you have these preposterous things crawling around on the ground, which that doesn't work either.

Maggy Benson: Dragging their bellies on the ground.

Matthew Carrano: Yeah, it literally doesn't work. And then we continually added to what we know about them, and now our view of dinosaurs is that in many ways, they stood and walked more like a mammal, very upright, very energetic animals. And so modern depictions are really reflecting that viewpoint now.

Maggy Benson: So these drawings and illustrations [00:06:00] that we see of dinosaurs walking and moving in different habitats, is that actually reflective of the habitats that dinosaurs were living in? Can we learn anything from that?

Matthew Carrano: It's a good question, because you look at these pictures. They're all very complete, in many ways. But in fact, most of the time, they're not very complete. And we sometimes have information. Sometimes we don't. You can look at a lot of these dinosaur pictures and really, it's like they're standing in a parking lot. There's nothing there. There's no plants. There's no other animals, really. That is not how ecosystems [00:06:30] work.

Matthew Carrano: Or you get this kind of very artistic, impressionistic view, and it's just kind of like, how maybe did it feel? And that's really what that kind of art is like. They're great for what they do, but they're not based on the science. Nowadays, we try to have all the pieces of these images be based on something, a fossil or an inference we've made from some piece of knowledge we have.

Matthew Carrano: So for example, here, if you took a time machine back 110 million years ago, without moving, [00:07:00] on the spot, this is probably what it would have looked like.

Maggy Benson: So in Washington DC, perhaps?

Matthew Carrano: Yep, Washington, D.C. You can go to Laurel, Maryland, to where those fossils were collected, and kind of a bayou, swamp environment. All those animals, we find those fossils.

Maggy Benson: So what kind of fossils are you collecting to be able to fill in those gaps to better understand what the flora looked like, the plant life, in these artists' drawings?

Matthew Carrano: Well, the ideal thing, of course, is that every time we go out, it's a jackpot, and we just keep finding skeletons of all the animals [00:07:30] that we want to study, but it never works that way. So we have to target places that preserve smaller fossils that are giving us a sample of all these other animals.

Matthew Carrano: It's very hard to find a whole skeleton of a very small thing, but you can find pieces of these things and identify them.

Maggy Benson: So that's what we're seeing here, with you in your office, are these collections of microfossils, which you've also brought here for us to see today.

Matthew Carrano: Yes, these are examples of those collections, exactly.

Maggy Benson: Very cool. So thank you so much for helping us understand a little bit more about the history [00:08:00] of paleontology and some of the small fossils that you get to be able to fill in those gaps.

Matthew Carrano: Sure.

Maggy Benson: Matt, let's learn a little bit more about your work with microfossils. You collect microfossils, as you said, to fill in the gaps, but I'm really curious about what studying them and comparing them actually reveals.

Maggy Benson: And before you jump into it, we're gonna ask our viewers again to start pondering that question.

Matthew Carrano: All right. That's good.

Maggy Benson: All right. We have another live poll for you to participate in. Tell us what you think. Microfossil comparison [00:08:30] reveals: Individual dinosaur behaviors? Dinosaur morphologies? Change over time? or Distribution of dinosaurs? Take a minute to think about it and put your answer in the window that appears to the right of your video.

Maggy Benson: [00:09:00] We're both watching the results come in.

Matthew Carrano: This is kind of exciting.

Maggy Benson: I know. It really is. The bars are changing quite a bit, but 50 percent of our viewers, now 45 percent, but still the majority, think that it shows change over time. What do you say?

Matthew Carrano: I think most people have gotten it right. Unlike last time, this was not a trick question, so really, that's the most common thing we use these types of fossils for. Each one of the collections we make of these fossils is like sampling an ecosystem. You're imagining a moment in time, and by getting more and more of these fossils, [00:09:30] we can actually look at how these ecosystems change through time.

Maggy Benson: Very cool. I think it's time to dive into one of your research sites. I know that you've studied somewhere called The Morrison Formation, an area with different rock layers.

Matthew Carrano: Right.

Maggy Benson: Can you tell us about that place?

Matthew Carrano: Yes. I work a lot in the western US. There's this great place to look for fossils, because the geology's right there. And in the Bighorn Basin, we have what's called The Morrison Formation. It's late Jurassic. It's produced many famous, famous dinosaurs, like stegosaurus. It has a particular layer [00:10:00] of rock, from a particular time. And then above that is another layer of rock that's later, called the Cloverleaf Formation. That's early in the Cretaceous period. I study both of these, but The Morrison is the one I wanted to show you some things from first.

Maggy Benson: And what did you bring to show us?

Matthew Carrano: Well, the exciting thing about The Morrison is that even though people have been looking for a hundred years, there's still new things to find. The biggest success for us was finding a lot of dinosaur eggshell. This eggshell, while it's not that rare, [00:10:30] finding any amount of it is really rare, and we found, essentially, ten thousand pieces of this stuff.

Maggy Benson: Now, how can you tell that's eggshell?

Matthew Carrano: Well, hopefully you can see it. It's actually curved like eggshell. It's quite thin. It has particular texture to it. Once you sort of understand what it looks like, you can spot it. You just have to sort of believe me with that, but if you come out with me, I'll show you how to do that.

Matthew Carrano: So once we found a lot of this in one place, we thought, "Okay, well, this is not just one little piece. There's something there in the rock that we want to get at." So we excavated [00:11:00] this huge site. It's a beautiful place to work, beautifully colored set of rocks. Right at the top of these outcrops was this layer. And so we pulled out huge blocks full of eggshell.

Maggy Benson: When you say there were a lot of eggshells, we're talking thousands of fragments?

Matthew Carrano: Yes, absolutely. I mean buckets, essentially, of this stuff. It's very hard to see, but it's a very thin layer, but in that layer, it's almost like a pavement, if you can imagine, of these crushed eggs. The way we look at them is we will cut them and look at [00:11:30] them in cross sections under the microscope. And that gives us a sense of how they're structured. So this very pretty picture here is showing you the side view of a slice of eggshell. You can see on the bottom these very kind of vertical crystals growing from the bottom, and then these horizontal layers above it.

Matthew Carrano: Together, that gives us some clue that this is probably a meat-eating dinosaur's egg, as opposed to a different kind of dinosaur.

Maggy Benson: Interesting. And what's this here?

Matthew Carrano: So this really pretty image is the same kind of thing, eggshell again, two of them on top of each other, [00:12:00] under what's called cathode ray luminescence. And that just means it's illuminating particular minerals. So here, calcite is orange.

Maggy Benson: So calcite is what eggs are made of? Even today?

Matthew Carrano: Yes, and it's in our bones and other things. It also is involved in fossilization. The most important thing here, though, is that vertical orange stripe in the top left. It's actually sediment with calcite filling a pore, which is like a tunnel through the eggshell. When the baby was in the egg, that's how gas would have passed in and out of [00:12:30] the egg so it could breathe.

Maggy Benson: So (with) all of this information that you were able to reveal with the imaging and with the fossil fragments, were you able to determine what type of animal or animals were inside these eggs?

Matthew Carrano: Yeah, we got really lucky, because normally, what I just showed you is how far we typically get. The eggshell gets you the category of dinosaur, but once we started to actually excavate, we were finding these tiny, tiny little bones. You can see this tooth here, very pointed, with serrations on it. Beautiful example of a predatory dinosaur [00:13:00] tooth.

Maggy Benson: That looks like a meat-eating tooth.

Matthew Carrano: Yep, and that is probably a millimeter or two across, and here's an example. You can see we found quite a few of these little bones. They don't look like a lot (but) under the microscope is really where you get the information.

Maggy Benson: As a non-paleontologist, I would not know that those were fossils.

Matthew Carrano: No, and in fact, it took a lot of work to really understand this. They're so small. The key, though, was finding this piece. And this piece was the tip of a snout of a dinosaur.

Maggy Benson: Oh, it's tiny.

Matthew Carrano: Yeah, again, doesn't look like too much. But [00:13:30] once we got it under the microscope, we had an artist do a drawing of it up close, and we could see that the bone has five teeth in it. On the bottom there of that drawing, you can see a few of them sticking out. He also was able to do kind of a digital sculpture of that, and again, as it comes around the other side-

Maggy Benson: Oh, now I can see it.

Matthew Carrano: You'll see these pointy little teeth. And because it has five teeth ... This is the important thing. In The Morrison Formation, there's only one dinosaur that has [00:14:00] five teeth in this bone, and that dinosaur is Allosaurus. And Allosaurus, thankfully, is a meat-eating dinosaur, so that works. So this tells us these are baby Allosaurus bones and this is an Allosaurus nest.

Maggy Benson: Wow! How interesting! I've seen the Allosaurus before, but I never really think of it as a baby or even think about its nest site.

Matthew Carrano: Yeah, and all dinosaurs have to be babies, and actually, the biggest dinosaur eggs are only about this big. And these are even smaller. So this animal gets to be 30 feet long and a couple tons.

Maggy Benson: That's a really cool example of how tiny fossils are revealing some new [00:14:30] information about dinosaurs. Do you have another example that you can share with us?

Matthew Carrano: Well, from the same site, what turned out for us that was really even more exciting that, if you can imagine, was the layer that buried the eggs was also full of fossils. These fossils were microfossils, really small things. And in amongst these microfossils, we got super lucky and we found a skeleton. And the skeleton is of a reptile, and you can sort of see the backbone here.

Maggy Benson: Oh, absolutely.

Matthew Carrano: In fact, here is the head of the animal.[00:15:00] The teeth are closed, the jaws are shut.

Maggy Benson: Oh, there it is.

Matthew Carrano: But it's actually a relative of lizards, not a lizard itself. It's called a rhynchosaur. Today, rhynchosaurs are only in New Zealand. The Tuatara is the last rhynchosaur in the world. But back in the Jurassic, they were super common and lizards weren't. So over time, the lizards have kind of taken over, and finding these animals here is part of understanding how that happened.

Maggy Benson: Very cool. So even now, [00:15:30] the rhynchosaur that lives now in the only place in the world, can actually find relatives of it from millions of years ago.

Matthew Carrano: And if you'd gone back 151 years, you would have seen them everywhere on Earth.

Maggy Benson: Very cool. So these are cool examples, but I'm still having trouble understanding how they fill all of those gaps in understanding the complete ecosystem picture.

Matthew Carrano: Yeah, I mean, these are really kind of highlights. It's not really about the ecosystem, in this sense. But in a different set of rocks, again, the Cloverleaf [00:16:00] Formation, this is above The Morrison. And then even above that, the Judith River in Montana, late Cretaceous. In these places, we have really extensive collections. Again, you see how pretty some of this stuff is? They're just really beautiful places to work, although it's really hot.

Matthew Carrano: In the Cloverleaf Formation, we have this environment that, from the rocks, we understood meant it was quite variable. There were lakes and streams and flood plains, and all these different places where animals could live, but we just had a few dinosaurs. I knew that if we went and looked for [00:16:30] these microfossils, we could potentially really fill in the story of these environments.

Matthew Carrano: So we spent six or seven years out in the field, finding all the places we could where this rock was at the surface and we could look at it. And we ended up collecting many thousands of microfossils from the Cloverleaf.

Maggy Benson: Now, seeing some of these microfossils that you've brought here today, and I know I'm not a paleontologist, but I'm really curious as to how you actually find these.

Matthew Carrano: Well, the finding of them isn't that different from finding a regular fossil bone like this, [00:17:00] where you're walking around and you're looking on the ground. But the trick is, of course, you're looking on the ground for something that's a lot smaller than a typical dinosaur bone. But you'll find them. You'll find little teeth and little bits of turtle shell, and when you get enough of them in one place, you start to suspect that, okay, there's something here in the layer that I'm interested in. Once we know that, we'll go in. We'll identify the layer. And we just collect the rock layer.

Matthew Carrano: This is us with just bags of dirt. We don't collect the fossil out of the rock yet. We take all of this dirt with us, usually a couple tons.

Maggy Benson: That [00:17:30] sounds like good exercise.

Matthew Carrano: It is very good exercise. And we do weigh it, so we actually know how much we collect. We used to wash it in the field, get rid of the extra sediment with a sieve. But we realized we were washing away some of the fossils when we did that, so nowadays, we do all of that in a lab. We just bring back the dirt; we don't do anything in the field. And we take care of it all here.

Maggy Benson: Matt, you actually showed me that process, the lab process of extracting the microfossils from the rock, which you've called matrix. Which I see a piece here that I recognize that.

Matthew Carrano: [00:18:00] Yeah, we've got a piece right here.

Maggy Benson: I think we should show our viewers how you do that.

Matthew Carrano: Excellent.

Maggy Benson: All right, let's have a look.

Maggy Benson: So Matt, you're showing us how we get tiny fossils out of pieces of rock. Where do you start?

Matthew Carrano: Well, we start with this, which we call matrix. This is a rock that's about 75 or 80 million years old, that we collected in Montana, last summer. This is kind of the treasure piece for us, because we can already see these very tiny black spots all throughout. And those represent fossils and pieces of fossils.

Maggy Benson: Wow. So all of these right here?

Matthew Carrano: Exactly.

Maggy Benson: So how do you get them out of there?

Matthew Carrano: [00:18:30] So the trick is to turn the rock back into the sediment that it started as, and the easiest way to do that is just to dissolve it in water.

Maggy Benson: Wow, that's pretty easy. So this right here is just the dissolved rock?

Matthew Carrano: Yeah, take a look and you'll see.

Maggy Benson: Oh, yeah.

Matthew Carrano: Not that different. Of course, it's a lot less solid. And you can see. . .

Maggy Benson: You can still see all the black flecks, which might be fossils.

Matthew Carrano: Yeah, so probably most of those are fossils. The next step will be to load that into a set of sieves. [00:19:00] (We'll) Give it a quick wash, just to clear out some of the first level of sediment, and then we'll get it ready for Duncan, where we do the longer term soaking.

Maggy Benson: So this is Duncan?

Matthew Carrano: This is Duncan. And we have a nice little machine here that will hold these trays. And as you can see, it will submerge pretty well.

Maggy Benson: So what's [00:19:30] the advantage of going a little slow with the dunking process?

Matthew Carrano: Well, the advantage for us is that the water doesn't move so fast that it actually grinds the fossils against one another in the screen.

Maggy Benson: So how long will these be dunked for?

Matthew Carrano: This will take a few days, not actually that long.

Maggy Benson: We don't have to sit here for a couple days while it runs, do we?

Matthew Carrano: No, fortunately, we've got one that's already dry, that we can take a look at.

Matthew Carrano: So these have now dried, these sieves. And [00:20:00] it's time to take a look at what fossils we have.

Maggy Benson: What's in there?

Matthew Carrano: You can take a look here in the top. Some of the dark brown elements. Here's a scale of a gar fish, right on the top.

Maggy Benson: Oh, right there. It looks like there might be another one, right next to it?

Matthew Carrano: Yeah, you've got one right there. And all told, there's probably a couple dozen fossils in this tray. If, however, we take a look below, at the smaller sieve, you can see a lot of really small black spots.

Maggy Benson: Oh, wow!

Matthew Carrano: Most of those are gonna be fossil material.

Maggy Benson: Really? Now, you're [00:20:30] gonna have to have a microscope to be able to see those, right?

Matthew Carrano: Yes, it's impossible for me to look at them just with my bare eyes, so we're gonna need to bag these up and take them up to the microscopes.

Maggy Benson: Awesome.

Maggy Benson: Matt, it was really cool to be in your lab, to be able to see that. I can see how it would be really addicting, finding fossils, even just in the lab. I mean, I, myself, found a couple fish scales.

Matthew Carrano: You did?

Maggy Benson: I have to give myself credit.

Matthew Carrano: It was very impressive, yes, and it is addictive. You really have to kind of watch yourself or you'll spend all day.

Maggy Benson: There has to be a huge team working on this with you, because of all of the sediment that [00:21:00] you have and all of the fossils that come out of it.

Matthew Carrano: Yeah, there's probably at least a dozen people involved. We have students and interns. A lot of volunteers help us out. We have a lot of different staff with different expertise here at the museum.

Maggy Benson: So let's get back to your research at the Cloverleaf Formation. What did you find after you actually extracted the microfossils from the sediment that you found there?

Matthew Carrano: Well, each site produces thousands and thousands of these fossils, and so this tray, for example, probably has 1,100 fossils, and it's one particular site. [00:21:30] And by example, you'll find tiny fragments of just all sorts of animals. So this example, these are armor from a crocodile. This is a jawbone of a very tiny amphibian. And there's also just many different kind of fishes, freshwater sharks, and other kinds of fish.

Matthew Carrano: All told, we end up with something like 50 or 55 species, whereas before, we had fewer than a dozen.

Maggy Benson: Do you have any other examples from that research site that you [00:22:00] can show us here?

Matthew Carrano: Well, one really nice example is this fossil here, and this is a lungfish. Lungfishes don't have teeth, in the sense that we do, but they have tooth plates. And they eat invertebrates and things. They kind of mash them up with these tooth plates.

Maggy Benson: So we're looking at the tooth plate here.

Matthew Carrano: Here's a close up you can see. There's a couple different kinds of lungfishes in the Cloverleaf. What's interesting is that lungfishes don't live in North America any more. They went extinct right after this formation. They're gone. Today, they live in places like Australia, South America. [00:22:30] And so the story of them kind of also petering out and going extinct is very important in this formation, because they're the last ones.

Maggy Benson: So what can you say, over all, about your research findings at the Cloverleaf Formation? You've found fish. You've found crocodilians, amphibians. What does that mean?

Matthew Carrano: Well, it's nice to have this fuller picture. That's really kind of cool, but having so many fossils allows us to actually start to look at the numbers of things, and we can look at how many species we have. On the top [00:23:00] you can see what's really interesting to me (which) is that dinosaurs are just a quarter of the species in this environment. Most things are fishes and crocodiles and stuff like that.

Matthew Carrano: And similarly, if we just count the specimens, dinosaurs are just a little more than a tenth of the specimens. So dinosaurs are not the most important things here. The most important things are the little animals. And if you went on a trip and took a safari and you counted everything you saw, most things are gonna be bugs and lizards and things, not rhinos and lions.

Maggy Benson: So really, you're painting the picture with [00:23:30] accurate data that shows that mammals and reptiles and amphibians are present in these dinosaur ecosystems, and actually how many of them were there.

Matthew Carrano: Yeah, I think the perspective we would have had a hundred years ago is just the dinosaur, with nothing else. And now, really, the dinosaur needs to be just a little piece of this big picture.

Maggy Benson: Thank you for helping us better understand a little bit about your research and microfossils. And we have a lot of student questions. We're gonna try to get to as many as we can.

Matthew Carrano: Great.

Maggy Benson: Ready to dive in?

Matthew Carrano: Absolutely.

Maggy Benson: All right. Mrs. Rhode's class sent a question. What was the [00:24:00] first fossil dinosaur you found?

Matthew Carrano: So the first fossil dinosaur I found was a piece of a duck-billed dinosaur. And this was in Wyoming, in about 1993. And I was on a trip with a bunch of graduate

students. I was a college student at the time. And it wasn't a very important fossil, scientifically, but it didn't really matter. It was like, I actually found it.

Maggy Benson: It would be very exciting. Mrs. Quintinill's 00:24:29] [00:24:30] class asks, how deep do you have to dig to get fossils?

Matthew Carrano: So that's a really good question, because I think there is a lot of digging involved, but it's not like digging a mine. We don't ever dig until you see something on the surface. If you just started digging holes, you'd never get anywhere. So, some of the fossil is right there. And then, depending on how big it is, that's how deep it goes.

Matthew Carrano: Every now and then, you get unlucky, and the fossil goes in that way [he motions straight down}, and you have to dig a lot. But [00:25:00] usually, it's a few feet. It's not that bad.

Maggy Benson: Sheldon Elementary asks, how are T. Rexes able to balance themselves on two feet?

Matthew Carrano: This is a good question. There's actually scientific research about what happens to a T. Rex if it falls.

Maggy Benson: Oh no.

Matthew Carrano: It turns out, nothing good. Yeah, so T. Rex has a very strong set of muscles, the hip and the upper legs, because it's incredibly important for this animal to stand and not fall. Once you're a certain size, falling is always bad. And [00:25:30] T. Rex is way above that size. So it's a very complicated set of bones and muscles that really take care of that for it.

Maggy Benson: This one's from Mrs. Miller's class. How does a dinosaur hatch out of its egg? Is it different for every dinosaur?

Matthew Carrano: So Mrs. Miller's class, you've asked a question that we don't know the answer to. Nobody knows what the method was for dinosaurs to get out of their eggs. All I can tell you is they must have had a way. Or they wouldn't have lasted very long.

Maggy Benson: All right. How long does [00:26:00] it take to find all of the fossil parts for one dinosaur?

Matthew Carrano: If you're lucky and you find a skeleton, then it's just a question of actually digging it out. And digging out a big skeleton can take weeks. Maybe a couple of months, if it's really big. If you don't have a connected skeleton in the ground and you have to go out and keep finding pieces, there are a lot of dinosaurs out there. I would say (that for) most dinosaurs, we don't have all the pieces for them yet.

Maggy Benson: This one's from Josh. Is oil more valuable than fossils?

Matthew Carrano: [00:26:30] Is oil more valuable than fossils? It all depends on what you want to do with it. So if you need to drive to the grocery store, then oil is more valuable than a fossil. If you want to learn about ancient life, then dinosaurs are more valuable than oil.

Maggy Benson: Great response. Matt, can you tell us a little bit about how you became interested in paleontology?

Matthew Carrano: Sure. Well, I got interested the way everybody gets interested, which is I was a kid who just thought they were amazing. [00:27:00] And in fact, when I was in second grade, this book, I noticed my friend Mike Devlin, who I haven't talked to in 25 or 30 years. Maybe he's out there. Thank you, Mike, by the way, if you are. Reading this book, and I saw these pictures, and I couldn't get enough of this, and these were totally fascinating to me.

Matthew Carrano: And I never kind of gave it up. Most people find something else that interests them. They just give up on the dinosaurs, and I just never found anything else that was as interesting. I had a museum nearby [00:27:30] that I could go to. I had a great library that I could go to, and so all that kind of kept me finding new things and new stuff to learn.

Maggy Benson: And now here you are at the Smithsonian, having fun in our fossil collections.

Matthew Carrano: Yeah, it's kind of amazing, even to myself, that here I am. I didn't imagine that in second grade.

Maggy Benson: Matt, it's been so fascinating hearing about your work, hearing more about dinosaurs and the microfossils that you study to better understand the ecosystems in which they live. Thank you so much for being here today.

Matthew Carrano: Well, thank you. This has really been great.

Maggy Benson: Can you tell our viewers where they can learn more?

Matthew Carrano: Yeah, so online, if you want to go online, [00:28:00] you can visit the Paleobiology Database. You can look up anything you want about any animal. You can also visit our own website, at what's called Dinosaurs in our Back Yard, and it's all about the dinosaurs in the D.C. Area.

Matthew Carrano: But where you live, there are probably fossils, so see what's there. You can just get out in the world and look for stuff. It may not be dinosaurs. It might be crinoids, it might be trilobites. Who knows? But just get out and handle things. Go the library. Go to a museum, if you can. Get yourself connected to the actual stuff.

Maggy Benson: Thank you so much, Matt. [00:28:30] Thank you so much for tuning in, and thanks for sending in all of your wonderful student questions.

Maggy Benson: If you missed part of this broadcast or want to see it again, it'll be archived later this evening at qrius.si.edu. Thanks again so much for joining us, and hope to see you next time on Science How?