Video Transcript – How Fossils Explain the Rise of Dinosaurs

Maggy Benson: Hans? Hans, are you in here? Hans?

Maggy Benson: How did dinosaurs get a foothold to become the dominant species on Earth at one time? We'll explore that question today with paleontologist, Dr. Hans Sues. Well, I guess he's back in the studio.

Maggy Benson: Wow.

Maggy Benson: Woo!

Maggy Benson: Hi, welcome everyone. Thanks for joining us for our season premiere of Smithsonian Science How, we're so happy to have you here. Today, we're gonna be exploring how dinosaurs rose to dominance, and here to help us unpack that question is paleontologist from the Smithsonian's National Museum of Natural History, Dr. Hans Sues.

Hans Sues: Hi Maggy, how are you?

Maggy Benson: Thank you so much for being here, Hans.

Hans Sues: Thank you.

Maggy Benson: So Hans, our story starts about 200 million years ago, when we know something major happened on Earth to allow dinosaurs to become dominant.

Hans Sues: Yes, 200 million years ago, something really big happened, and it was a so-called mass extinction, and as a result, dinosaurs became dominant on land.

Maggy Benson: Let's ask our viewers what they think caused this massive event.

Hans Sues: Good idea.

Maggy Benson: Viewers, here's an opportunity to participate in a live poll with us. Tell us, what major event happened on Earth 200 million years ago? Was it massive flooding? Huge volcanic eruptions? An asteroid hit? Or dramatic climate change? Take a moment to think about it, and put your answer in the window to the right of your video screen, and remember that this is the same place that you can post questions for our scientist, Dr. Hans Sues to answer, during our live program, and Dr. Antoine Bercovici, who's also in the chat.

Maggy Benson: Hans, we're both taking a look at the responses coming in, and it looks like the majority of our viewers, 56 percent right now, think it was an asteroid impact. What do you think?

Hans Sues: Well, scientists thought that for a long time as well, but in this particular case, there's no asteroid involved.

Maggy Benson: So, as a paleontologist, you piece together clues from the geologic record to be able to put together a story. Where does our story start?

Hans Sues: Our story starts in the Triassic period, which started about 250 million years ago, and ended 200 million years ago, with this great extinction that we're gonna talk about.

Maggy Benson: So I see something that is familiar to me from the ocean, does it have anything to do with marine animals?

Hans Sues: Yes, this is actually a marine animal, this is the shell of a squid-like animal called an ammonite, they were incredibly common during the Triassic period, really, in the oceans. They probably fed on plankton; some of the larger ones probably were also meat-eaters that fed on other things, including other ammonites. And 200 million years ago, scores and scores of species of these animals vanished, and in fact, the lineage almost went entirely extinct, only a few forms made it through the extinction, and then subsequently gave rise to a host of new forms.

Maggy Benson: Were there any other marine animals that didn't make it through this massive event?

Hans Sues: Yes, in fact, a lot of bad things happened. A lot of sponges went extinct, and for a long time, sponges were actually the major organisms that made up reefs before modern corals took over that role. Many clams, snails, all kinds of organisms. There were microscopic organisms called conodonts, which kind of look like little jaws.

Maggy Benson: Which we're looking at now.

Hans Sues: Or tooth-like structures, these are microscopic structures that are very much sought by geologists, because they use them to date rocks when they're looking for oil and gas. Then here we have a marine reptile, this large, lizard-like reptile that is about 10 feet in length, called a Thalattosaur. All of these animals, this huge diversity of marine life, just vanished very quickly.

Maggy Benson: Wow, all of that?

Hans Sues: Mm-hmm (affirmative).

Maggy Benson: So, is there any evidence of an extinction event on land?

Hans Sues: Yes, and we actually see a very similar pattern, lots and lots of lineages of animals and plants vanish. The plant communities go from really species-rich with all kinds of conifers and ferns and other kinds of plants, to basically

dominated by certain types of conifers that were adapted to living in hot and dry climate.

Maggy Benson: So the animal makeup at this time, what was it like in the Triassic?

Hans Sues: Well, here we have some animals that lived on land during the Triassic. Here's a little creature which basically would've looked like a little horned lizard on steroids called Hypsognathus, a little plant eater.

Maggy Benson: What are those things on its side?

Hans Sues: These are little spikes that protected it, presumably against predators. Also, this one actually was killed by a predator, because there's a huge tooth hole in the snout.

Maggy Benson: Wow.

Hans Sues: But these spines would've prevented it from being swallowed; there are some living animals that have similar spines-

Maggy Benson: Where would they be? On their face?

Hans Sues: Right on their cheeks, so if the predator tried to take the prey head-on, they would get stuck and get [crosstalk]

Maggy Benson: They would get stuck.

Hans Sues: Yeah. So this is one type of Triassic animal that completely vanished. And this is an early amphibian, this relative of frogs and salamanders today. They grew up to about, skulls alone, almost eight feet in length, and body over 20 feet in some cases. And then here's a gliding reptile, has these huge, long ribs, and they supported the little gliding membranes, so they went from tree to tree, kind of like a flying squirrel.

Maggy Benson: Wow, and all of that went totally extinct.

Hans Sues: All of those totally vanished.

Maggy Benson: Hans, you showed us a really amazing collection of amphibians, is that the same as this?

Hans Sues: Yeah, this is actually the same species, this is a little guy.

Maggy Benson: Well, we got to go behind the scenes here at the Smithsonian to take a look at a collection of those same amphibians. Let's show our viewers.

Maggy Benson: Hans, this is awesome.

Hans Sues: Yes, this is part of a graveyard of Triassic amphibians, and these lived in a large river system, they died, their bodies fell apart, and then the river washed all of these bones together.

Maggy Benson: So this isn't actually a dinosaur, then.

Hans Sues: No, this is a relative of today's salamanders and frogs.

Maggy Benson: So you said these went extinct about 200 million years ago?

Hans Sues: And that was an important ecological change, because then afterwards, crocodilians come on the scene and take over in that role. The largest skulls get up to about two feet in length, with an overall length for the animal of 10 feet.

Maggy Benson: Did they have large teeth?

Hans Sues: Yes, they did. In fact, you can still see stumps of the teeth that tend to cut, were used to kill the prey. So they would just sit there with their mouth open, until something swam by and then just grab it.

Maggy Benson: So where was this found?

Hans Sues: This is from New Mexico, from a place called Lamy, but these kinds of animals lived all over North America.

Maggy Benson: I'm glad they're not in our rivers today.

Hans Sues: Oh yes, you wouldn't want to go fishing and find one of these guys.

Maggy Benson: Thank you so much, Hans.

Hans Sues: You're very welcome.

Maggy Benson: Hans, I'm still happy that those are not in our rivers today.

Hans Sues: Oh yeah, absolutely.

Maggy Benson: I think I saw an image of what these might've looked like when they are alive a little bit earlier, they looked like pretty massive amphibians.

Hans Sues: Yeah, imagine a cross between an alligator and say, a hellbender, large salamander, so.

Maggy Benson: So, were they the top predator of the Triassic period?

Hans Sues: They were in lakes and streams and on land. There were other kinds of top predators, some of which also would go into the water much like modern

crocodiles. There's a group, for instance, called the phytosaurs. There's a really nice example of one called Smilosuchus. This animal has a skull length of up to six feet, and here's a reconstruction of the whole skeleton, these were gigantic predators, and they would basically eat anything they wanted. We have gut contents for some of these animals and they basically ate everything else in the ecosystems.

Maggy Benson: I wouldn't wanna be around those guys either.

Hans Sues: No, these creatures were serious predators.

Maggy Benson: So this is a whole new cast of characters that is brand new to me. I mean, what did the Triassic really look like?

Hans Sues: Well, basically, the Triassic was a world where all the continents formed one huge landmass called Pangea, climates were really warm in most places, in some places, they were very dry, and other places quite wet, and it's very different from the distribution today. And these are some of the creatures, this is a scene from the American Southwest, where we have a particularly good fossil record, so places like New Mexico, Arizona, and Texas, here's another one of those phytosaurs like Smilosuchus.

Maggy Benson: Like the crocodile-like animal?

Hans Sues: Here's an early relative of mammals called Placerias, a big plant eater, about the size of a large cow. Yes, very massively-built animal. And then here's another kind of crocodile-like animal, a harmless plant eater that had massive body armor to protect it against all those big predators running around.

Maggy Benson: You're saying that's harmless?

Hans Sues: Yep, this was a harmless little plant eater, and those spines basically protected it against being bitten on the neck and the shoulder region, where a lot of predators would attack you.

Maggy Benson: Just like Hypsognathus, I guess, like this one.

Hans Sues: Yeah, except this one had even better body protection, so.

Maggy Benson: Is this part of the body protection?

Hans Sues: Yeah, this is one of the armor plates from his back, so you see, this thick, bony plate that would've been round on the other side, and then there was a smaller plate of, and ending in a spike, to the side of that, so.

Maggy Benson: How large did that animal get?

Hans Sues: This is from an animal called Typothorax, and they got up to about eight, nine feet.

Maggy Benson: Some big animals.

Hans Sues: Mm-hmm (affirmative). Yeah.

Maggy Benson: So, thanks for helping us understand what animals went extinct, but we still don't know why they went extinct. You mentioned something about an asteroid impact?

Hans Sues: Yeah, that was the first idea, because there's a huge crater in Quebec, in eastern Canada, that was once thought to be about 200 million years old, we now know through new and improved radiometric dating, where you use radioactive elements to determine the age of the rock, that it's actually about 20 million years too old, so.

Maggy Benson: So if it wasn't an asteroid, what was it?

Hans Sues: Well, and that is actually what we're gonna have an example of here; this is a chunk of basalt.

Maggy Benson: Right here?

Hans Sues: Yeah, this is lava that cooled down and formed basalt. And the answer is that it was an unparalleled episode of volcanic activity that happened when the supercontinent started breaking apart. The first break that we see here, actually, this is an example of what this would've looked like. You have just massive amounts of lava pouring out of the Earth. It's not the kind of explosive volcanism that people think. When a volcano erupts, you generally see, where suddenly the whole mountain blows apart, but this was like a slow and steady supply of just enormous, billions of tons of lava that came out, and this happened all along what is now today the North Atlantic Ocean. So when you look along the east coast of North America, you look in Morocco, you look in France, all the way down to West Africa and to Brazil, you have these massive layers of basalt that poured out at the time. It's an area of about 2.7 million square miles that was covered by volcanic rock.

Maggy Benson: So this basalt is 200 million years old, and the same kind of basalt can be found in all of those different locations.

Hans Sues: Absolutely, and this piece is actually from the Palisades Sill, which you can see, if you're standing in Manhattan, and you look across the Hudson River, you see these great cliffs.

Maggy Benson: Millions of people see that.

Hans Sues: Yeah, and that's where it's from, that's the Palisades Sill, and this is this kind of volcanic rock here.

Maggy Benson: So as a paleontologist, you're constantly putting together clues, and this basalt must've been a huge clue as to this major extinction event. So you mentioned that there were these huge eruptions happening, and I can imagine life getting wiped out that were nearby, but global extinction?

Hans Sues: Well, one thing that happens when large amounts of lava come out of the Earth, they have dissolved gas, because it's molten rock, and it's full of dissolved gas, that gas is released into the atmosphere. And there're different kinds of gases, you have your classic greenhouse gases like carbon dioxide, which just poured out in enormous quantities, and there's also sulfur dioxide, which is another kind of gas, when it goes up in the atmosphere, it bonds with the water and the clouds, and forms sulfuric acid droplets. That's bad enough, but those droplets actually reflect the sunlight, so for a while, things actually cooled down, but then the CO2 accumulates, and we get really warm temperatures, the atmosphere warms up enormously.

Maggy Benson: So this map here, this says it's early Jurassic, is this what it looks like after that volcanic activity?

Hans Sues: This was after the main volcanic action, so you see the North Atlantic is opening, there's a little bit of an indication, already of the Caribbean, the Gulf of Mexico.

Maggy Benson: What was the temperature like because of that?

Hans Sues: At that time, it was really hot, I mean, you know, you're looking at places, probably average temperature's between 90 and 100 degrees.

Maggy Benson: Wow, that's hot!

Hans Sues: Throughout the year, and some places were basically really hostile to life, we know that there were vast deserts in much of the world, and those would've been very hostile to life.

Maggy Benson: So the students that selected climate change and volcanism were both correct in that one question.

Hans Sues: Yeah, because at that point, there was just so much volcanic activity that climate change was, all the gases going up in the atmosphere led to massive climate change.

Maggy Benson: Massive changes on Earth.

Maggy Benson: So Hans, we've discovered what major extinction event killed off the dinosaurs, but we still haven't discovered what allowed dinosaurs to really get a foothold and reign on Earth. Before you tell us, let's ask our students again.

Hans Sues: Absolutely!

Maggy Benson: Viewers, here's another opportunity to participate in a live poll with us. Tell us, how did the dinosaurs become dominant? They preyed on all of the other species? They got bigger than the other species? They were the only ones left after the extinction? Or they out-competed other extinction survivors? Take a moment to think about it, and put your answer in the window to the right.

Maggy Benson: Well, an overwhelming majority of our viewers think that they preyed on all the other species. What do you think?

Hans Sues: Well, that's a good idea, but the more likely explanation is that all of the competition had vanished, those big crocodile-like animals, both plant eaters and meat eaters had vanished, and so they suddenly had opportunities to make a living that didn't exist for them in the Triassic, and this facilitated them growing much larger. Of course, it's actually a good thing to be large, because it A, protects you from predators, and B, it allows you to use the ecological resources much more efficiently.

Maggy Benson: So something had to survive the Triassic, a dinosaur had to make it through that event to be able to actually grow into this niche.

Hans Sues: That is correct.

Maggy Benson: Who made it?

Hans Sues: Well, both predatory and plant-eating dinosaurs made it, so we can see here, it's little Coelophysis, the little dinosaur running in the middle of the painting.

Maggy Benson: The blue and red one?

Hans Sues: Yeah, the blue and red one, and we have here a close relative of Coelophysis called Syntarsus from the early Jurassic, so after the extinction, and this is already a larger animal than Coelophysis. It has this little crest on its head, and actually lived at the same time and the same place where an even larger relative of Coelophysis lived, Dilophosaurus, which had two big crests on its head.

Maggy Benson: And those are some pretty sharp teeth.

Hans Sues: Yeah, this is clearly a meat eater, these are little, basically little steak knives.

Maggy Benson: What else made it through the extinction event?

Hans Sues: We have, along with the meat-eating dinosaurs, we have a number of plant-eating dinosaurs, such as the Massospondylus, which was an animal that grew up to about 15, 20 feet in length-

Maggy Benson: It looks huge!

Hans Sues: ... from South Africa, and these were very robustly-built plant eaters, and these ultimately are related to the giant sauropod dinosaur, Brontosaurus and Diplodocus that became dominant much later, the largest plant eaters of all time. But small things survived too, here's a modern tuatara, which is a little lizard-like reptile that lives in New Zealand, and it was part of a group that was enormously diverse during the Triassic, survived into the Jurassic, and did very well.

Maggy Benson: So you mentioned in one of those responses to the student questions about T. rex not reigning until way later after the Triassic. Well, were there any T. rex relatives after this extinction event?

Hans Sues: Well, along with these early relatives of Coelophysis, there were also very early precursors of the Tyrannosaurs. So the first Tyrannosaurs that we can really recognize as Tyrannosaurs show up about 160 million years ago, and these are nothing like the T. rex that we know. These were much more lightly-built animals, these were animals built for running, they reached a length somewhere between 15 and 20 feet, they had like strange crests on their head as well, and so they didn't look anything like a T. rex. These were animals that were adapted for running fast, for slicing meat, which T. rex is a really stockily-built animal that has massive teeth so it could eat flesh and bone, I mean it would just grab things and just crush the-

Maggy Benson: Now, the most recent Tyrannosaur looks scary, but they all looked like they were serious predators.

Hans Sues: Oh yeah, these were all serious predators, even the early ones already were like the top predators in their day.

Maggy Benson: You mentioned another top predator of the early Jurassic, Dilophosaurus, can you tell us about that animal?

Hans Sues: Yeah, Dilophosaurus is actually a close relative of Coelophysis, it has these two big crests on its head, it's very, sort of paper-thin. In fact, they were at first not even, that people thought it was just crushed bone, but they're actually separate structures that were on the snout, and they presumably were used to either advertise males to females, or as a sort of species recognition device.

Maggy Benson: The other day, you took me behind the scenes here at the Smithsonian to take a look at some Dilophosaurus trackways. Let's show our viewers.

Maggy Benson: Hans, this is so cool! What are we looking at?

Hans Sues: We're looking at part of a dinosaur trackway. So we have this area here of mudstone, and this was a mudflat near a lake, and you can see a really large dinosaur footprint there, the three toes, like a giant bird footprint, and here's another one, this one's particularly nice, because you can actually see the little impressions that the claws left. These tracks were left by large meat-eating dinosaurs, similar to the Dilophosaurus, which was the top predator around 200 million years ago. But these dinosaurs, just like humans, walked fully upright. So that's why you can see, these are two different feet, so this animal would've just taken one big stride, and then the next stride would be off the block already.

Maggy Benson: So you said this was one of the top predators 200 million years ago. Was it competing with Tyrannosaurus rex?

Hans Sues: No, Tyrannosaurus rex came much, much, much later, 65 million years ago. Tyrannosaurus rex is much closer to us than to this guy.

Maggy Benson: Interesting, so an ancient relative.

Hans Sues: Yeah.

Maggy Benson: Hans, thank you so much for sharing that with us, that was very cool. So Dilophosaurus was really king at the early Triassic, and, I mean, the sharp teeth, I wouldn't wanna mess with them.

Hans Sues: No, definitely not. (laughs)

Maggy Benson: So Hans, you and I are sitting here today, and we are mammals. So what survived in the order of mammals from this extinction event? Something had to, right?

Hans Sues: Yeah, and it did, and actually quite a few types of things survived. We have little close mammal-like reptiles here called Kayentatherium; this is one example of one.

Maggy Benson: How can you tell it's a mammal?

Hans Sues: It's a close relative of mammals, it's not actually a mammal yet, but it already has most of the mammal-like features, like just one bone in the lower jaw, and then these very elaborate cheek teeth. Mammals chew their food, and so early on, mammals evolved teeth to help with really helping to break down the food. Now, one advantage that mammals had in addition to chewing their food is that mammals and their relatives early on were really small animals, and small animals fare much better in extinction events than large ones.

Maggy Benson: So this animal right here, can you pronounce it for us?

Hans Sues: This is called Kayentatherium. This is from Arizona. Here's a small specimen, about the size of the one that we have the skull of here, and then here is a really large one, this is one that grew up to having a skill about a foot in length, so.

Maggy Benson: So Hans, we're looking at this animal right here this pre-mammal, if you will, the Dilophosaurus and the cousin of the Dilophosaurus that made it through. What determined who lived and who died after this major extinction event of the Triassic?

Hans Sues: Well, that's one of the really interesting questions for biologists, can you predict who would fare better in a major extinction event, during a major environmental crisis? What species would do well, which species would be more likely to become extinct? And generally, it's true that small species that have very broad ecological adaptations, that can eat a variety of foods, that have specialized behaviors that allow them to deal with major environmental change, do well, whereas the big, specialized animals are much more likely to go extinct. So in the modern world, if you look at a mouse or a rat, they thrive under almost any conditions imaginable, whereas an elephant or whale, have very specific food requirements, very specific environmental requirements, and if they change, they're much more likely to become extinct.

Maggy Benson: Interesting, thank you so much for sharing your research here with us. We have so many student questions that I think we should get to some of them.

Hans Sues: Oh, absolutely!

Maggy Benson: All right, this question comes from Audily. "Have you ever found any unique dinosaurs or discovered a new type of dinosaur?"

Hans Sues: Yes, I have already discovered a number of new dinosaurs, in fact, right now I'm working on species number 10, a new kind of Tyrannosaur from Asia.

Maggy Benson: That must be lucky, lucky number 10. This one comes from Isabella, Tamia, and Chelsea. "Are there more dinosaurs that are fuzzy and furry?"

Hans Sues: Well, it actually turns out that a lot of the meat-eating dinosaurs were fuzzy, they had sort of little hair-like structures, in some cases, really feather-like structures on their bodies, and that's how modern birds evolved their feathers in the first place. Feathers didn't evolve as for flight, but initially evolved, presumably, to keep these warm-blooded animals warm.

Maggy Benson: This question comes from Madeline and Mishka. "Where did you get the foot printed soil from?" So that trackway that we saw behind the scenes.

Hans Sues: That's a good question, this trackway comes from Virginia, there's a major stone quarry, and they found layers and layers of rock with hundreds of tracks, and that's where it comes from.

Maggy Benson: From OC fifth grade, "Did any bird-like dinosaurs survive?"

Hans Sues: Yes, actually, most of the meat-eating dinosaurs are already very bird-like in their features, and in fact, researchers have now shown with many new fossil discoveries, especially from China, that birds originally came from little meat-eating dinosaurs.

Maggy Benson: Nevine wants to know, "Were there any dinosaurs that survived underwater?"

Hans Sues: Actually, contrary to a lot of popular books, there weren't any dinosaurs in the water; there was one dinosaur that may have spent part of its life in water. It's a giant predator called Spinosaurus, and there's some recent research that shows that it most likely made much of its living eating fish, and was also, had anatomical features that suggest that it spent a lot of time in water, kind of like modern crocodiles.

Maggy Benson: We have another question, but this one's a video.

Hans Sues: Okay.

Riley: Hi, I'm Riley, and I wondered if the volcanoes hadn't happened, would humans still exist?

Hans Sues: That's a really good question Riley. We may not have come into being, because as long as there were dinosaurs and other large reptiles around, early humans would've had a really difficult time to make a living, so it's probably a good thing that these creatures are no longer around, and let our species become what it is now.

Maggy Benson: This question comes from Jade, Ella, and Aden. "How could a T. rex be so big, and its hands so tiny?"

Hans Sues: Well, that's a really good question, and there's really no good answer to it. It's just, during the evolution of Tyrannosaurs, their arms got smaller and smaller, they were still strongly-built arms. In fact, one of my colleagues argued that T. rex could've lifted just with the strength of its upper arm about 800 pounds, so they were used for something, but we really haven't figured out what it is yet. They're too short to reach the mouth, so they probably were not really helpful for the T. rex during eating, there really is no good explanation as yet.

Maggy Benson: This one is from Sophia and Marcello. "Which dinosaur is the most dangerous?"

Hans Sues: Actually, I would put my money on creatures like Velociraptor, and Deinonychus, and all those sickle-toed predatory dinosaurs, they were very lightly-built animals that could probably jump really well, and with the huge killer claw on their second toe, their long hands with other big claws, and a mouth full of teeth, they would've been really nasty customers to deal with.

Maggy Benson: We're getting some awesome questions, but we're just about out of time. Hans, can you tell all of our viewers, and maybe future paleontologists how you got into this field of paleontology?

Hans Sues: Sure. Actually, a lot of kids go through a dinosaur phase. I got into this early on when I was about four years old. I had a book on prehistoric life, and it turned out that when I looked at the plates in this and saw these wonderful reconstructions of lost, ancient worlds, that I just got hooked, and I stayed with it. I studied geology and biology, and became a paleontologist.

Maggy Benson: Hans, thank you so much for being here today.

Hans Sues: You're very welcome.

Maggy Benson: Where can our viewers learn a little bit more about your work?

Hans Sues: Well, the Smithsonian has some excellent websites, there's one on dinosaurs, there's one on geological time, and you can also, when you look for very staff scientists, like my colleague, Dr. Matthew Carrano, who's the curator of dinosaurs, he and other people have detailed descriptions of what they do for scientific research, and you can learn more through that. The other thing is the other great resources out there, there's something called The Paleontology Portal, and the University of California at Berkeley Museum of Paleontology has a fantastic website on fossils.

Maggy Benson: Thank you so much, Hans.

Hans Sues: You're very welcome.

Maggy Benson: And thank you so much for all of your awesome questions. If you missed part of this show, it'll be archived later this evening at qrius.si.edu. Thanks for joining us, and we'll see you next time on Smithsonian Science How.