



Out of the Ashes: Dawn of the Age of Mammals

[crickets]

[footsteps]

[cymbal plays]

[chime]

[music plays]

[NARRATOR:] It was the end of one world and the beginning of another. Sixty-six million years ago, an asteroid more than six miles wide struck the earth, triggering a mass extinction.

[TYLER LYSON:] It wipes out all the large dinosaurs, these animals that had dominated the landscape for the last 180 million years.

[IAN MILLER:] Plants also experience a big extinction...

[LYSON:] ...60 to 80% of birds go extinct, amphibians. For the most part, it just wipes the slate clean.

[NARRATOR:] From the ruins of a devastated planet, a new world would arise in which mammals dominate instead of dinosaurs. But how did mammals seize the moment? How did life even recover from the catastrophe?

[LYSON:] That's what I'm interested in. How long did it take for ecosystems to recover? For habitats to re-form? A thousand years? A million years?

[NARRATOR:] The answers have been difficult to find. But now, a breakthrough in Colorado. A remarkable new trove of fossils is starting to reveal how the modern world began.

[SHARON MILITO:] That's gotta be the skull...

[LYSON:] A big skull.

[music plays]

[NARRATOR:] The asteroid impact blasted a massive amount of material into the atmosphere. Some of it rained down and triggered wildfires across the globe. Debris, soot, and an enormous plume of vaporized rock blocked out the sun. Global temperatures plunged by as much as 20 degrees Celsius.

[ANJALI GOSWAMI:] So you're talking about immediate global winter. That would have cooled the environment and really stopped basic production of the materials that we need for life. Things like photosynthesis would have been really shut off immediately.

[NARRATOR:] The blackout lasted for years. Food chains collapsed, wiping out the dinosaurs and about three-quarters of all plant and animal species. The animals that survived tended to be small and lived in the water or burrowed underground.

[GOSWAMI:] And so if we want to understand the world today, if we want to understand the organisms and the diversity of life on the planet today, we really need to be able to draw back, all the way back, to that event 66

million years ago. And to that critical period right after that event that completely shaped what life was going to look like today.

[NARRATOR:] Over time, the atmosphere cleared. Sunshine and warmth returned to the planet, and life began to recover. But to understand how, scientists have to find fossils of the right age. Around the world, a thin clay line contains the fallout from the asteroid and marks the boundary between life before the impact and life after it.

[NARRATOR:] In a place called Corral Bluffs, near Denver, Colorado, 400 feet of rock lie above the boundary. It was deposited in the first one million years after the mass extinction. That makes it a promising location for scientists to try to trace the recovery of life.

[LYSON:] At Corral Bluffs, my team and I are trying to reconstruct the ecosystem right after dinosaurs went extinct at 66 million years ago. Corral Bluffs preserves the first one million years of time after the extinction of the dinosaurs. So, we are looking for things like mammals, turtles, crocodiles, birds, and plants and trying to combine all that into a reconstruction of the environment.

[NARRATOR:] One way scientists can reconstruct the plant community is by pulverizing rocks and looking at them under a microscope. The sediment contains thousands of fossilized spores and pollen.

[MILLER:] Right after the boundary, there's this explosion of fungal spores. The thing is, fungus grows on things that are dead. So most of the world must have been rotting.

[music plays]

[NARRATOR:] But then, above the fungus, signs of renewal.

[MILLER:] Following immediately on top of the fungal world, we see a spike in fern spores, and that shows a world blanketed in ferns that probably lasted a few thousand years.

[NARRATOR:] Ferns are better able to germinate in denuded landscapes than other plants. They're often the first plants to reappear after forest fires and volcano eruptions. Next, in rock layers above the ferns, scientists see signs of new plant life.

[MILLER:] One of the big surprises was this incredible abundance of palm fronds, huge, beautiful palm fronds. They're so dominant it feels like the world is all palms.

[NARRATOR:] By 300,000 years after the extinction, a forest canopy has returned. Underneath, plant diversity is rebounding. The rich vegetation provides food and new potential habitats for animals. But animal fossils are hard to find here and anywhere else from this time period.

[LYSON:] Big layers here. When you're out looking for fossils, it's all about search image. And the first search image you're taught as a paleontologist is to look for bone, look for the teeth, look for the actual stuff.

[NARRATOR:] But the actual fossils were elusive. The team found almost no trace of mammals.

[MILLER:] I can see it from here.

[LYSON:] You can see it, yeah.

[NARRATOR:] Until volunteer Sharon Milito explored these bluffs.

[MILITO:] I was an elementary teacher for 30 years and while I was teaching, I had the opportunity to go up to the Denver Museum of Nature and Science at night and take their paleontology certification courses. So being certified by the museum allowed me to participate in all kinds of field experiences with the museum. This is a piece of a crocodile. It's an osteoderm.

[MILITO:] So, one day I was walking along in an area I'd been many times before, and I saw this white round rock sitting there on kind of its own little pedestal. And I picked it up and looked at it, and as soon as I looked at it, I saw these teeth that were just smiling out at me. And I just almost had a heart attack.

[NARRATOR:] Sharon had found a rare treasure: a mammal jaw.

[LYSON:] And I was absolutely astonished. I couldn't believe it. I'd never seen a mammal from this time period this complete. And I was thinking to myself, well, if there's this complete of a skull here, there's got to be more.

[NARRATOR:] The fossil had been found inside a type of rock called a concretion. Sometimes concretions form around organic material, like bone. Under the right conditions, concretions can protect a fossil inside for millions of years.

[engine revs]

[NARRATOR:] Spurred on by Sharon's find, the team returned to Corral Bluffs to search for concretions.

[LYSON:] We're gonna systematically do all of this. I have this new search image in mind, and I see this concretion on the ground, the very first one that I pick up, and I crack it, and it was amazing. I just found a mammal skull!

[laughs]

[LYSON:] And wasn't five minutes later that Ian brings a concretion to me and sure enough, it has a skull inside of it. And then Sharon, she brings a concretion over to me, and sure enough, there was another skull. And so, within a five-, ten-minute interval, we found five or six mammal skulls.

[LYSON:] You can very clearly see the cross section of a tooth here and another tooth here. This is the snout. If we look on the side here, we can see a bunch of teeth here, here, here, and here. This is one of the most complete Paleocene mammal skulls ever found. Right here.

[LYSON:] Sharon, come have a look. Look at that! Oh man, I am over the moon. I think this is one of the biggest discoveries that I've ever been a part of in my entire life, so, I mean, I am beyond excited. What's next?

[MILLER:] It was crazy the way it happened. I mean, you could go your entire career as a mammal paleontologist and not find a skull from this time period. That's how rare they are.

[NARRATOR:] In the thrilling months that followed, the team discovered dozens of mammal fossils, as well as crocodile and turtle fossils. The spectacular collection is the world's largest, best preserved group of early mammal fossils from this time period. The discoveries reveal how plants and animals evolved together. For example, this mammal species lived about 300,000 years after the asteroid strike. The teeth in the front of its mouth would have been good at tearing into flesh. The flatter back teeth were for grinding greenery.

[LYSON:] So one of the things that we learned just with this particular animal is that it ate both meat as well as plants. Being a generalist in terms of diet is something that we see in many animals in the early aftermath of the K-T extinction.

[NARRATOR:] Higher up the cliff, Tyler found this fossil of a large beaverlike creature that lived about 700,000 years into the recovery. It had large, flat teeth it probably used on the wider array of leaves and stems now available.

[MILLER:] So as the recovery proceeds, you see these bizarre creatures show up on the landscape, and we think it's because they're specializing with new plants that are showing up as well in those ecosystems.

[GOSWAMI:] In those original few hundred thousands of years where mammals went from these tiny generalized or insectivorous animals into very quickly starting to take advantage of all these ecosystems and becoming these big plant-eating animals.

[NARRATOR:] The change in size was dramatic. Within just 700,000 years after the mass extinction, and with the dinosaurs gone, some mammal species were now larger than any mammals had ever been in their previous one hundred million years on the planet. That explosive growth made the scientists wonder, what could have fueled it?

[footsteps, students talking]

[NARRATOR:] An important clue turned up when Ian Miller led a group of students on a fossil-hunting expedition to Corral Bluffs.

[MILLER:] This one student, her name is Aeon, and she hands me this rock and she's like, what's this. Did you get something? So I took it up, looked at it in the light and lo and behold it was the middle part of a bean pod.

[AEON WAY-SMITH:] Um, I found this legume two seconds ago from this rock that's sitting in my lap.

[MILLER:] Legumes today are things like soybeans, alfalfa, of course the peas that you eat on the dinner table.

[NARRATOR:] As it turns out, this is the oldest legume ever found.

[MILLER:] She just pushed back the fossil record of legumes by 4 million years. And made them North American. You brought 'em home. That's awesome.

[WAY-SMITH:] It makes me feel special, actually, because I didn't even know what it was at first when I found it.

[NARRATOR:] Aeon's legume was alive right when the size of mammals exploded.

[MILLER:] At 700,000 years into the recovery phase, we see the appearance of legumes, and legumes are like these protein bars for the new mammals on the landscape. And we see a whole new class of animal sizes show up at that moment.

[music plays]

[NARRATOR:] The fossils at Corral Bluffs reveal how, in just one million years, the void left by the dinosaurs was filled by plants and animals evolving hand-in-hand.

[GOSWAMI:] No organism evolves or lives in isolation, right? Everything about them really reflects their interactions with their environment, with other species, even with other individuals in their species.

[MILLER:] The period we call the recovery is this important moment where we see this new interplay of life of the animals and the plants, and they evolve together, and it's really sort of the starting point of the modern world.

[music plays]

[NARRATOR:] Mammals took over a revitalized planet and branched into many groups, one of which eventually produced us. Our roots then go all the way back to the recovery and the dawn of a new age. Our age. The age of mammals.

[music plays]