[SHUBIN:] Our planet is teeming with many kinds of animal life. Including groups with defining structures, such as the four legs of land animals, the feathered wings of birds, and the dexterous hands of primates. Understanding the origins of these structures, and of the groups that possess them, has long been a central quest of biology. Charles Darwin asserted that each kind of animal must have evolved from pre-existing, earlier kinds of animals that lacked those structures. He boldly predicted that buried in the crust of the earth were animals that connected one major group to another. Such transitional fossils would be intermediate in form between earlier and later groups. What made Darwin's prediction so bold was that, at the time he stated it in "On The Origin Of Species," no such fossils had been found. His critics immediately latched on to the admission that transitional animals are somehow "missing" from the fossil record. Over the decades, it's become a standard talking point for those who have closed their mind to the science of evolution.

But, in fact, since Darwin, paleontologists have unearthed hundreds of transitional creatures that have enabled us to reconstruct the origins of many groups. And even so, searching for such fossils remains a challenging adventure, and finding the right one can change the way we think about the origins of living creatures. For me, paleontology has always been about filling the gaps in the story of life. And for a long time, one of the biggest ones was understanding the origin of animal limbs, with fingers and toes. Paired limbs are a feature of many animals, but there's little at first glance that suggests the limbs of different species are related. On frogs they're springy. On elephants not so much. They're feathered on eagles. Not on bats. But inside the limbs of mammals, amphibians, reptiles and birds, one finds a common architecture.

Here's a dog. Dogs run and jump. What do you have? One bone, two bones, little bones, and then the digits, the equivalents of the fingers or toes. And, of course, here's a bird, it flies, its limb has been modified into a wing and it has: one bone, two bones, lots of bones, and digits. The amazing fact is every four-limbed animal walking the Earth today has this fundamental pattern. … One bone, two bones, little bones, fingers. That pattern suggests a connection between these very different groups of animals.

And it's not the only feature they share. They also all have a backbone—they're vertebrates. The history of vertebrates has been captured in rock we can accurately date. Fossils reveal when each of these groups of animals first emerged. The youngest group is the birds. Go further back in time and you'll find the first mammals, … and then the first reptiles, … and the first amphibians.

And then you get to 370 million years ago. Suddenly, there are no four-limbed creatures, or tetrapods, anywhere to be found. Where the first tetrapods came from has always been one of the great mysteries of biology. I mean it's not like there weren't animals or vertebrates around, 400 million years ago. There were. But they were all … fish.

Did four-legged animals come from fish? Fish might seem unlikely candidates to be the earliest ancestors of frogs, horses and humans. They don't even have limbs. They have fins. Despite their different external appearances, there are revealing similarities. First, fish and tetrapods are vertebrates. And early in life, when they are embryos, they look remarkably similar. Finally, DNA analysis shows that fish are tetrapods' closest relatives. All of this suggests four-legged animals did indeed come from fish.

But how did a fish with fins give rise to tetrapods with four legs? As a young scientist, I wanted to find fossils that could help answer that question. I knew it wasn't going to be easy. The world's a big place, the earth is a giant planet, and fossils are very small, so how do you find those things? Well there's a checklist we run through. We look for places in the world that have rocks of the right age; … you know, if you're interested in the origin of dinosaurs, there's one age of rocks you look at; if you're interested in the origin of land-living creatures there's another age of rock.

Then you look for places in the world that have rocks of the right type, the kind of rocks that are likely to hold fossils. A lot of things have to come together for an animal to be fossilized. For starters, it has to be in the right kind of setting where sediments form. And soon after it dies, it has to be buried—before its remains are ravaged by decay, weather or scavengers. The dirt and mud burying it has to harden sufficiently to protect what's left for thousands or more likely millions of years. After which, something, say erosion, has to bring the embedded remains to the surface. And then, someone who cares about such things, like me or my longtime colleague Ted Daeschler, has to wander by and find it.

The fossils I wanted to find would have been alive in the Devonian era, between 365 and 385 million years ago. But where could we find the right kinds of rocks from that era? I remember sitting in the office. And we were doing the sort of usual banter one day about something geological. We had a college textbook and we were just thumbing through the diagrams in the book and, boom, there was this figure that changed our lives. I remember seeing that and saying to myself "Holy cow, this is what we're looking for."

It was a map of North America which highlighted three areas of Devonian rock of just the right type to hold fossil fish moving onto land. Two of those areas had already been worked on, so we focused on the third: the Canadian Arctic. My heart was racing when I saw that because … and I'm sure yours was too, I mean, no paleontologist had worked on that, expressly looking for early tetrapods.

Then you dug out the aerial photos and that's when I got kind of terrified. I remember seeing this for the first time and thinking, "You gotta be kidding me!" Look at all this snow, how do you work there? The Arctic presents some unusual challenges. You're far from help, so you have to bring everything you'll need. And you have to move fast, because the season is short, and you don't want to be there when the weather turns. So when the helicopter drops you off in the Arctic for the first time, you're standing here saying, "What am I doing here?" You know, you're thinking about polar bears, that's the first thing you look for. Is there anything in the landscape? Everything in white becomes a polar bear when you're first here. The last thing on your mind are fossils. It's hard to believe, when you look out across this frozen terrain, that once this was a warm, watery world swimming with life. There's this huge disconnect between the present and the past.

What we see today is a valley with red and green rocks that are tilted and stacked one on top of the other, but that's not how it was in the past. These valleys have been carved by glaciers that have moved back and forth, and those red and green rocks actually at one point extended across the valley and they were straight, they weren't tilted. Now look inside the rocks and what those rocks tell us that this valley, 375 million years ago, was a giant floodplain and that floodplain was filled with rivers that swelled their banks and sometimes shrunk, but in those conditions formed swamps and streams of all different sizes. And inside those streams was diverse life. Including, we suspected, a fish with features that would ultimately enable animals to walk on land.

But even if it had been there, could we find evidence of it buried on one of the nameless hillsides that had built up and eroded over the past 375 million years. So how do you find fossils?

I pick up a lot of stuff, right, sometimes it's just a piece of rock, sometimes it's bird poop, sometimes it's a leaf, but occasionally it's a jaw with teeth in it. So what you begin to learn is to tell the difference between white which is not bone and white which is bone, teeth, or scale. Once you have that in your mind, then you start to apply that search image to other rocks.

Here's another scale here that stands out like a sore thumb. And then we go; … if you look around, right here, … so this is the underside of a skull. So you never know where you're going to hit it around here and so that's why we keep on looking.

But that first expedition ended without finding what we had come for. And as our second trip drew to a close we were still searching.

Then, a bit before our scheduled departure, we had a real scare. The team had separated and the idea is everybody needs to return back to camp by radio call.

"Hey, you guys see Jason?"

"No, I haven't seen Jason, have you seen Jason?"

I said, "I asked you that question, you didn't see Jason?"

And all of a sudden, it became, "Where's Jason?"

This is our youngest member, we were looking out for him the entire season, and no Jason. I mean my heart was really beginning to race. Then I hear footsteps outside the tent, and there's Jason. His eyes are like globes, and he says "I found it! I found it!"

Every pocket was burgeoning with bones. These bones, he's laying down on the table one after another. It's daylight 24 hours a day, so we ran down to Jason's site, and as soon as we came to this bluff here and looked down, we saw why Jason was so excited. Because beneath our feet were fossil fish bones, fragments of fossil fish, many of them, thousands of them. It wasn't just one fish, it was a whole aquarium, it was different species.

It got better, because as we walked up the hill and we followed that carpet of fossil fragments, it stopped, meaning it likely came from one layer. And if we had any luck at all we'd find that layer and see what's inside. Hard as we tried, we couldn't discover what was buried in Jason's hill before we had to leave. But we kept coming back to it in following years, to dig, chip, and search.

The second week of July in 2004 we're all working in series in this hole. My head is right next to Farish's feet, and Farish's feet is next to Steve Gatesy, and we're digging together, and Steve says, "Hey guys, what's this?"

Ted and I go running over to see what Steve was referring to, and what we saw … was this V here, it was covered with rock. And as soon as we saw this V, and we saw these teeth under it, it became very clear that this little V we're seeing is the tip of a snout, and that this was a snout of a flat-headed fish. And it was sticking out of the rock, so if we had any luck whatsoever, the rest of the creature would be encased in the rock.

And here it is.

What's really wonderful about this specimen is that we have pretty much the whole thing, and the whole thing is put together. That is, the head is connected to the body. And the body is connected to the fins. So we know that this fin comes from this body. And when we put it all together we see this creature's about four feet long, and some of the biggest were about nine feet long.

What's really amazing is that this is an animal that Darwin would have predicted. A real mix of characteristics, a combination of fish-like and tetrapod-like features. Like a fish, it has scales on its back, and it also has fins, with fin rays. But like a tetrapod, it has a flat head with eyes on top. And when we look inside the body, what we see are these huge interlocking ribs that suggested that it had lungs. When you put the body and the head together, you see it had a neck, where the head can move independently of the body. What that means is this animal could use the neck to peer outside the water, find prey, and avoid predators.

So we've many bones of these animals, including this one, which is a hip bone of these creatures and what it reveals is that the hind fins were already evolving into legs while these animals were living in water.

I get really excited when I see the front fins of *Tiktaalik*. Here's one from one of the large specimens. And what you see is the shoulder, but also some of the fin bones inside. What you see is a version of the one-bone, two-bone pattern that's inside our own arms. You have one bone, two bones. You even have a version of a wrist. And once those fins were strong enough to lift its body out of the water, a whole new frontier opened. Over millions of years the two pairs of fins in fish like *Tiktaalik* would lead to the two pairs of limbs in every tetrapod.

So what does this all mean? What it means is that our arms and legs are derived from the paired fins of our fishy ancestors.

So how fast did this transition happen? Well, we know that *Tiktaalik* didn't exist in a vacuum. There are other creatures, other transitional fossils, that are more fish-like and others that are more tetrapod-like. And these creatures existed for over 15 million years.

So what this means is that this great transition from fish to tetrapod didn't happen in a single step, but happened gradually over time. The discovery of *Tiktaalik* made headlines because it is one of the earliest in a series of fossils that illuminate the transition from water to land.

And that's just one key transition that fossils have shed light on. One of the very first was the evolution of birds from feathered dinosaurs. That's now one of the best documented transitions in the story of life. What it and other well-studied examples tell us is that what at first seems to be huge leaps are almost always products of a series of smaller evolutionary steps. That's true for when our fish ancestors first came to land, when dinosaurs took to the air, and when we first stood upright.