The Origin of Species: Lizards in an Evolutionary Tree

[NARRATOR:] The diversity of animals on our planet is breathtaking. Millions of species adapted to all kinds of habitats. Ever since Darwin, understanding how so many species evolved has been a major quest of biology, and biologists like Jonathan Losos. In the Caribbean, he's studying a remarkable group of lizards.

[LOSOS:] She will be back.

[NARRATOR:] He's finding clues to their origins, in their bodies, their lifestyles and in their DNA.

[RESEARCHER:] Well, there's one out there.

[NARRATOR:] These lizards are providing fresh insight into both how new species form and why our world is filled with so many creatures.

[LOSOS:] Don't think I don't see you, lizard.

[NARRATOR:] Here in Puerto Rico, Jonathan is stalking lizards called anoles.

[LOSOS:] Okay, here we go.

[NARRATOR:] With almost 30 years of practice, he's a pro at catching them.

[NARRATOR:] Come on. There we go. He's okay. They've got very strong necks. This actually doesn't hurt them at all. He's healthy. A fine looking specimen.

[NARRATOR:] Puerto Rico's anoles all feed on similar food, mostly small prey like spiders and crickets. But they divide up their habitats in a clever way. The long-tailed, slender species Jonathan caught lives in grasses and bushes, and is called a grass-bush anole. On the low parts of tree trunks and on the ground, a longer-legged, stockier species forages, called a trunk-ground anole. And higher up the tree lives another anole species.

[LOSOS:] On twigs and small branches like these, we find very small anoles with really short legs.

[NARRATOR:] This slender lizard is called a twig anole. Further up the tree is yet another species.

[LOSOS:] High up in the canopy there's a large green lizard with big toe pads. He lives high off the ground. There's one right there.

[NARRATOR:] Like apartment dwellers, each species lives in a different vertical space. But here, each floor offers unique evolutionary opportunities to its inhabitants. The fact

that lizards differ in leg length and toe pad size, depending on where they live, suggest that these differences in traits are adaptations to the lizards' habitats.

[LOSOS:] Here's a good tree over here.

[NARRATOR:] To test whether that is in fact the case, I came here to help Jonathan conduct some experiments.

[LOSOS:] Yeah, these lizards are very cooperative.

[NARRATOR:] We begin by comparing the running ability of two lizards.

[LOSOS:] Short legs, yeah.

[NARRATOR:] One with long legs, the other with short ones.

[LOSOS:] Let's do some tests. Let's start with this little lizard here and see how fast it can run up this broad surface.

[CARROLL:] All right. I'll catch him if he makes it to the end.

[LOSOS:] All right. Here we go. There he comes.

[CARROLL:] Wow. She's a sprinter!

[LOSOS:] Exactly. She lives at the bottom of trees right in the open. She catches prey on the ground, so she has to run down quickly to get them.

[NARRATOR:] The shorter-legged twig lizard is not nearly as fast. It seems like a disadvantage. Why aren't their legs longer?

[LOSOS:] If you'll hold that...

[NARRATOR:] Jonathan puts a twig lizard on a thin branch to demonstrate.

[LOSOS:] All right. Let's see how he does. Here we go.

[CARROLL:] Looks pretty comfortable there.

[LOSOS:] Yup.

[CARROLL:] Just sort of scurrying along like a balance beam.

[LOSOS:] This is what they love.

[NARRATOR:] Instead of speed, the twig lizard's legs provide a firm grasp.

[LOSOS:] All right. Now let's try the other one.

[CARROLL:] So this is the sprinter?

[LOSOS:] This is the sprinter. Let's see how she fares on this little stick. Look how ungainly she is. Her legs are too long for this. So you can see on these narrow surfaces, long legs are a disadvantage.

[NARRATOR:] On twigs, long legs only increase the chance of falling. So ground lizards have evolved long legs and twig lizards short ones that enable their lifestyles. Next, we compare how well two species can climb the slick surfaces of leaves. Anoles have different size toe pads on their feet. We'll see if these help them navigate different environments.

[LOSOS:] So it's time for Lizard Olympics part two.

[CARROLL:] All right, I'm game for that.

[LOSOS:] Here's the ground lizard. Let's see if he can hang on and move up it. Oh.

[CARROLL:] No.

[LOSOS:] He couldn't even hang on.

[CARROLL:] Cannot hang on.

[LOSOS:] Let's try it again. There he goes. He's getting up there. He's able to move up but not very easily. All right, let's do another species.

[CARROLL:] All right.

[LOSOS:] Take a look at this guy.

[CARROLL:] Oh, my goodness. That's an anole?

[LOSOS:] This is the big canopy lizard. Let's see how he does.

[CARROLL:] Well that's not a fair contest. He's huge. There's no way for him to hold up his weight.

[LOSOS:] What do you think now, smart guy?

[CARROLL:] Okay. He proved me wrong. Pretty impressive.

[LOSOS:] He's using the little microscopic hairs on his toe pads to bond with the surface. And that's what holds him up.

[CARROLL:] And his toe pads are bigger than other lizards?

[LOSOS:] Yes, they are. Even... he's a bigger lizard but even for his size, he has particularly large toe pads.

[CARROLL:] So this is an adaptation?

[LOSOS:] This is an adaptation because he cannot afford to fall out of the canopy.

[NARRATOR:] But how do these adaptations arise? Jonathan and his colleagues wanted to see if they could observe the lizard's traits evolve by conducting another kind of experiment. Their inspiration was the rapidly-changing environment of some of the smallest Caribbean islands. Hurricanes occasionally swamp these tiny islands, scrubbing them free of lizards. The team realized they could use the depleted islands as laboratories. They began their experiment by capturing tree dwelling anoles on a larger island.

[RESEARCHER:] Well, there's one out there.

[LOSOS:] Yeah. Good.

[NARRATOR:] Then they visited seven islands that a hurricane had cleared of lizards. On each, they placed a female and male anole. These islands have no trees, only small bushes.

[RESEARCHER:] In the sun or in the shade?

[NARRATOR:] How would the long-legged lizards fare on thin branches? The next year the scientists returned.

[LOSOS:] She will be back.

[NARRATOR:] They found that the mating pairs they had introduced not only survived but reproduced. And the new population had grown and taken to living on thin branches.

[LOSOS:] And now she's in my noose.

[NARRATOR:] The scientists collected the lizards.

[LOSOS:] So the height off the ground... Every time we found a lizard, we measured how high it was off the ground.... 40 centimeters. The diameter of the surface....

[RESEARCHER:] Okay.

[LOSOS:] And whether it was perched head up, head down or horizontal.

[NARRATOR:] They brought them back to their field lab, took X-rays to precisely measure the length of their legs, and scanned their toe pads. Then they returned each lizard to the exact spot where they had found it.

[LOSOS:] Okay, all right.

[NARRATOR:] Now they had baseline data on the new populations. A year later, they came back.

[LOSOS:] All right, I think he gave us the slip. Oh! Excellent!

[NARRATOR:] And discovered that the average lizard leg had shortened in just two generations.

[LOSOS:] We thought maybe this is just a fluke, a statistical accident. In fact, over four years, the populations all got shorter and shorter and shorter legs. Evolution can occur very rapidly when natural selection is strong.

[NARRATOR:] Adaptations like these explain how different body types evolve. But they do not explain how new anole species arise. It's changes in other traits that play a key role in speciation. Two groups of animals are defined as different species when individuals from one group don't mate and reproduce with those from the other. So for a population to become a new species, something has to prevent its members from breeding with members of closely related populations. This is called reproductive isolation. One way a species can split into two is for populations to separate geographically. Over many generations, they can undergo enough changes in their respective habitats, that if and when they come back together again, they don't mate. So what kind of changes keep anoles from mating? Anoles have a flap of skin under their throats called a dewlap, which males display to attract females. And remarkably, every species in the same area has a different dewlap. So a change in a dewlap is a critical step in the formation of new anole species. [CARROLL:] Jonathan, why would these dewlap colors change?

[LOSOS:] Consider this grass lizard that lives here in the forest where it's relatively dark. And if we look at its dewlap, you can see it's pretty light-colored. Now suppose that a population of these lizards ended up in an area that was much more open and sunnier. In that case, a light-colored dewlap isn't very effective. So overtime the population would evolve by natural selection to have darker dewlaps. And we might end up with this one. And he's got a much darker dewlap. Much more visible in a light, open habitat.

[NARRATOR:] If for some reason these two populations come together, the females would no longer recognize the males as members of the same species. They wouldn't mate. They would be reproductively isolated.

[CARROLL:] There's a simple connection between changes within populations, or microevolution, and the formation of new species, or macroevolution. When changes

within populations include traits involved in mating -- like dewlap color -- then the stage is set for the formation of new species.

[NARRATOR:] Once new species have formed, competition drives the evolution of different body types. Species living in the same area compete for resources. But if members of one species move into another habitat, they can use resources not available to the other species. Over many generations, natural selection favors traits that enable species to occupy different habitats. This process has led to the body types we see in Puerto Rico. And not just there. On each of the Caribbean's four largest islands -- Puerto Rico, Jamaica, Cuba and Hispaniola --we find the same distribution of similar-looking lizards.

[CARROLL:] Now you'd think that all the lizards on the different islands would look different. But they don't. Each island has the same basic body types.

[NARRATOR:] Each island has slender grass-bush anoles with long tails... long-legged trunk-ground anoles... short-legged twig anoles... and canopy anoles with large toe pads. How did each island end up with the same body types? Did each body type evolve once and then spread to the other islands? Or did each type evolve independently on each island?

[RESEARCHER:] So I'm going to be sequencing some additional markers for the....

[NARRATOR:] To find out, Jonathan and his colleague sequence the DNA of anoles from each island. They examine the same stretch of DNA from many species to uncover their evolutionary relationships.

[LOSOS:] Species that are more closely related, we wouldn't expect to have many differences in their DNA. For example, these two species here, if you go across here, there's only one base pair where they're different. That's because they're very closely related. On the other hand, this species here has many differences... here, here, here and here. That's because this species diverged from the other ones a long time ago.

[NARRATOR:] After determining which two species were most closely related, they joined them together with a node representing a common ancestor. Then they joined these to the next most closely related, until all the lizards were united in a phylogenetic tree. The DNA revealed a pattern consistent with this: Lizards on each island tend to be more closely related to each other, than to similar-looking lizards on different islands. That means that generally the same types of lizards evolved independently on each island.

[CARROLL:] On all of the large Caribbean islands, the same traits have evolved again and again. Body color. Limb length. Toe pad size.

[NARRATOR:] Moreover, this repeated filling of habitats on each island by anoles illustrates why our planet has so many species.

[CARROLL:] The simple reason why there are so many species in the world is that there are so many habitats.

[NARRATOR:] And each habitat provides numerous ways to survive. In the Serengeti, zebras eat the tallest, coarsest grass. Wildebeests, the medium-height grass. And Thomson's gazelles, the shortest. In the Galapagos, some finches primarily eat seeds on the ground, and others, insects in the trees.

[CARROLL:] Look around you, in your backyard or around the world, there are so many different environments, each full of creatures making a living in a different way.