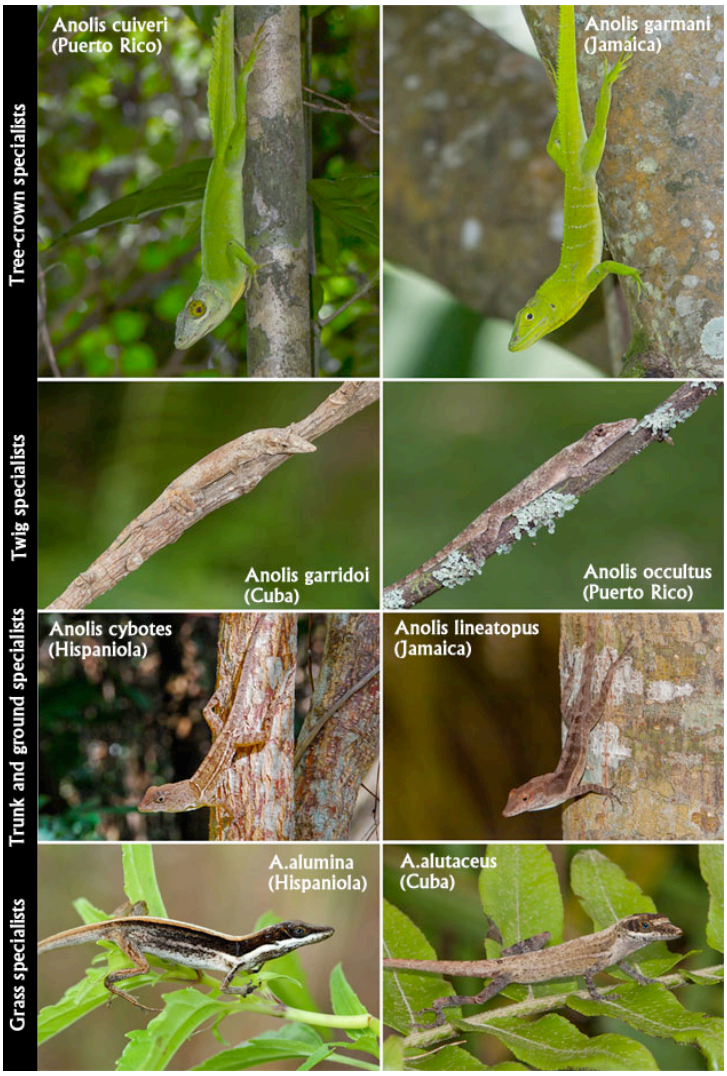
Lookalike Lizards and the Predictability of Evolution

by Ed Yong

When Luke Mahler started his PhD, he had one stipulation. "I wanted to work on anything but anoles," he says. Anoles are small, color-changing lizards that are abundant in the Caribbean, and especially in the Greater Antilles. Hundreds of species live on these six islands, and most evolutionary biologists would regard them as dream subjects. That's because the anoles are an extraordinary example of convergent evolution—where different living things independently acquire the same adaptations to the same challenges.



For example, each island has an anole that lives among twigs. They have prehensile tails, short legs, a lichen-like pattern on their back, and slow, creeping movements. But these aren't the same lizard. They're not even close relatives. Those on Cuba evolved their camouflaged colors, twig-like bodies and erratic movements independently from those on Puerto Rico, Jamaica or Hispaniola. But because they've adapted to the same ecological opportunities, these lizards have ended up looking so similar that even experienced biologists would have trouble telling them apart.

The same applies to the islands' grass-dwelling anoles, or their trunk-hugging anoles. "If you weren't an anole biologist and someone came down, blindfolded you and put you on a different island, you'd think: Oh yeah, those are the same lizards," says Mahler.

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Jonathan Losos has made a career from studying the Caribbean anoles—everything from their behavior, to their genes, to their running abilities. So, when Mahler joined his lab as a student, he wanted to pave his own way. "I thought it was all played out," he remembers. "It's all been done. And the Caribbean's not badass enough, and I want to go to Africa."

But the anoles sucked him in. While Losos had found many impressive examples of convergence between various anole species, he hadn't yet looked at *all of them*. If you measured every anole in the Antilles, exactly how convergent would they be? "Jonathan said: Why don't you do that?" says Mahler. "I thought: Surely someone has done that. He said: No. I said: You're kidding me."

This matters because evolutionary biologists have long argued about how repeatable evolution is. "There's always been a sense that the answer is not very much," says Mahler. "Evolution is highly idiosyncratic. There are so many inputs that can influence the course of evolution at any moment that you're unlikely to see repeated outcomes."

Stephen Jay Gould, for example, famously imagined that if we could replay life's tape from some point in the past, evolution would head down very different paths. Others challenged that view, and pointed at the many examples of convergent evolution. If living things repeatedly end up in the same destination, surely this implies that they only ever had a finite number of routes for getting there? By that logic, if you replay life's tape, you'd get more or less the same result.

This is where the anoles come in. They've effectively carried out Gould's thought experiment across the Antilles. These islands have much the same climate and very similar plants. If you put the same lizards on all of these islands and wait for them to evolve and diversify, do they produce the same forms or very different ones?

To find out, Mahler measured 100 of the 119 anole species in the Greater Antilles, including the length of their bodies, tails and legs, and the number of sticky pads on their toes. All of these are "battle-tested" traits that affect how well the anoles survive in the wild. And when he plotted all the data on a single graph, the results were very clear: most of the anoles were more similar to those on other islands that you'd expect by chance. Across the board, these lizards were converging on similar forms.

Together with Travis Ingram for Harvard University, Mahler developed several mathematical models to try and describe the pattern of anole evolution. The one that most closely matched the actual data relied on the concept of an "adaptive landscape"—a metaphorical terrain of peaks that represent opportunities for species to evolve towards.

That's what the anoles seem to have done. Despite living on different islands, the anoles faced the same adaptive landscape with the same niches to exploit. As they diversified, they ended up converging on the same peaks. "There's a substantial and undeniable element of repeatability," says Mahler.

Walter Salzburger from the University of Basel praises the study, and says that Mahler's team have effectively used statistical methods to prove what others had suspected based on their observations. "The paper is extremely well done and one of the best examples we have that evolution does repeat itself, at least when beginning with similar ancestral material," adds Dolph Schluter from the University of British Columbia. "Striking cases of convergence, not just of individual species but diverse sets of species like the anoles, tell us that evolution is much more predictable than we thought."

Of course, this doesn't mean that evolution is wholly deterministic. There are still surprises, especially on the larger islands which house a wider range of habitats. For example, the Hispaniolan hopping anole (*Anolis barbouri)* is unique—it's a leaf litter specialist, and the only anole that lives entirely on the ground.

Still, the anoles show that evolution can be more deterministic and repetitive than what Gould had envisaged. **"**We don't want to overemphasize the similarities between these islands but there's certainly the same themes cropping up again and again," says Mahler. Replay the tape of life, and you'll be greeted with familiarity as well as novelty.

Other diverse groups of animals provide more evidence for this. Salzburger, for example, studies the cichlid fish of Africa's Lake Tanganyika and Lake Malawi. These fish have also diversified to a spectacular degree. Some graze on algae, others chase down small prey, and others pick the scales of larger fish. Cichlids in the two lakes have independently converged upon the same lifestyles, as have some cichlids *within* each lake.

"I know a lot of folks who are very interested in using our landscape approach to look at these cichlids," says Mahler. There are many more species of these fish than there are anoles, and they are harder to measure, but Mahler adds, "The cichlid community is just on fire and I think they'll probably get some answers pretty soon."