

[steps]

[music chime]

[music plays]

[DIAL (narrated):] The evolution of flight in birds has long been a great scientific puzzle.

[music plays] Fossil evidence from the past 40 years has established that birds descended from theropods, a lineage of two-legged dinosaurs that included species with feathers on their bodies and arms. But those early animals could not fly. So how did birds take flight?

[music plays] A new hypothesis came from my studies of young birds that are learning to fly. And it all started with a bale of hay.

[DIAL (narrated):] I've been studying the mechanics of bird flight for over three decades at the University of Montana's Flight Lab. I became interested in an intriguing question that critics of evolutionary theory had posed to Darwin.

[DIAL:] So, there's a gentleman by the name of Sir George Jackson Mivart. He challenged Charles Darwin when Charles wrote *The Origin of Species*.

[DIAL (narrated):] Darwin had proposed that structures evolved through intermediates. So a wing would have evolved from a forelimb in stages. But some of those early stages were clearly not capable of flight. Mivart confronted Darwin.

[DIAL:] He said to Darwin, "How do you explain, in the evolution of birds from reptiles, the function of half a wing?"

[music plays]

[DIAL (narrated):] So to answer that question, I looked to a living example: bird chicks with small, immature wings. I wanted to make careful observations of how chicks use their wings as they learn to fly.

[DIAL:] I was keeping the birds on these shiny floor, clean lab conditions, and trying to have them go up a wall that was slick, to fly up to their siblings. As soon as a rancher came in once and said, "What are these birds doing on the ground? They HATE being on the ground! Give them a bale of hay, give them something to get up on!"

[DIAL (narrated):] As soon as I got some hay bales for the chicks, we made an interesting observation.

[DIAL:] I came back one day and my son who had been helping me, I asked him, "How are they doing? How was the data today?" And he says, "It was horrible." I say, "Why?" He says, "They were cheating."

And that moment, a watershed moment in my life... "What do you mean they were cheating?" "They ran straight up, vertically!" I said, "That's impossible..."

[music plays]

[DIAL (narrated):] To better understand this behavior, my son Terry and I decided to carefully measure how young birds use their legs and wings together to travel up ramps of different angles.

[DIAL:] So here is our little experimental animal here.

[DIAL (narrated):] My friend Julia Clarke, an expert on the evolutionary origin of birds, joined us on our experiments. The first angle is not steep.

[DIAL:] It's wild. This is not a... [CLARKE:] Not a trained animal.

[DIAL:] This is not a trained animal.

[wing flapping]

[CLARKE:] That was easy.

[DIAL:] Just walked, no problem.

[CLARKE:] Strolled.

[DIAL:] Nonchalant, no wing necessary.

[DIAL (narrated):] Next, we try a sharper angle.

[CLARKE:] Ok, so this is much steeper than before.

[DIAL:] It is.

[CLARKE:] Let's see what happens.

[DIAL:] There we go.

[JULIA:] You are not sure what you see. Because it's so fast.

[DIAL:] And until you see it in slow motion, you don't know how beautiful it actually is.

[DIAL (narrated):] This time, the bird used its wings as it ran.

[DIAL:] And every time it felt like it was falling backwards, it used its wings. Not to pull it up, and this is what we discovered. It wasn't to lift it up and take it like a bird flying straight up to this refuge. It was using its wings to pull it forward onto this log.

[DIAL (narrated):] And now, a really steep ascent.

[DIAL:] That is going to be a challenge, right?

[CLARKE:] So, this is now nearly vertical.

[DIAL:] This is vertical. Standing tall, vertical like any tree. Let's see what the animal can do to negotiate this. It can fly, but...

[CLARKE:] But it's still using its legs. Still using its legs.

[DIAL:] It climbed with its legs, using its wings to pull it towards the tree, but not to fly it up the tree. Pretty cool.

[DIAL:] This has turned out to be not just representative of the bird we looked at. But every flight-capable bird that we've looked at in the 15 years since. Dozens and dozens of birds.

[DIAL (narrated):] I have also observed the same behavior in the wild. And I've even seen young birds use their wings to assist their hind limbs to paddle across a body of water.

[CLARKE:] So Ken, how did this change the way we think about how dinosaurs get in the air?

[DIAL:] Well, we now know that there are a lot of dinosaurs, little feathered theropods that have little wings. And the explanation for their existence is really difficult to resolve. And I think that a reasonable explanation is to look at what young birds with similar wings can do today. Birds show us the possibility of what these dinosaurs could have done.

[DIAL (narrated):] Scientists have long debated two main possibilities for how flight evolved. Dinosaurs could have used their clawed hands to climb up trees and then glide down, with this gliding behavior eventually evolving into flight. Or dinosaurs could have run faster and faster on the ground, flapping their wings, and some species then evolved the ability to fly. But our research suggests a third possibility.

[DIAL:] So every bird that we've looked at, dozens of different species, do this behavior. They exhibit this behavior of flap and running. No gliding. They don't jump off of a bale of hay and glide down. And they don't fly up. They flap-run up, and they flap down.

[DIAL (narrated):] Juvenile theropods might have used their forelimbs similarly. In the adults, the legs alone were probably sufficient to escape predators or to hunt down prey, but in growing theropods, small wings provided an advantage.

[DIAL:] Just imagine the selective pressure at the time of theropod dinosaurs. Everything's trying to eat everybody, chasing everybody. If you could've moved up to an elevated refuge, with the use of these little wings, you would have lived to see tomorrow.

[DIAL (narrated):] Those young theropods would have run up to escape predators, and then flapped back down when it was safe. Over time small wings evolved into larger ones, until these feathered dinosaurs were able to take to the air.

[music plays]