EXPLORE THE ISSUE BEING INVESTIGATED

Unraveling the Mystery of How Geckos Defy Gravity

Science is most fun when it tickles your imagination. This is particularly true when you see something your common sense tells you just *can't* be true. Imagine, for example, you are lying on a bed in a tropical hotel room. A little lizard, a blue gecko about the size of a toothbrush, walks up the wall beside you and upside down across the ceiling, stopping for a few moments over your head to look down at you, and then trots over to the far wall and down.

There is nothing at all unusual in what you have just imagined. Geckos are famous for strolling up walls in this fashion. How do geckos perform this gripping feat? Investigators have puzzled over the adhesive properties of geckos for decades. What force prevents gravity from dropping the gecko on your nose?

The most reasonable hypothesis seemed suction—salamanders' feet form suction cups that let them climb walls, so maybe geckos' do too. The way to test this is to see if the feet adhere in a vacuum, with no air to create suction. Salamander feet don't, but gecko feet do. It's not suction.

How about friction? Cockroaches climb using tiny hooks that grapple onto irregularities in the surface, much as rock-climbers use crampons. Geckos, however, happily run up walls of smooth polished glass that no cockroach can climb. It's not friction.

Electrostatic attraction? Clothes in a dryer stick together because of electrical charges created by their rubbing together. You can stop this by adding a "static remover" like a Cling-free sheet that is heavily ionized. But a gecko's feet still adhere in ionized air. It's not electrostatic attraction.

Could it be glue? Many insects use adhesive secretions from glands in their feet to aid climbing. But there are no glands cells in the feet of a gecko, no secreted chemicals, no footprints left behind. It's not glue.

There is one tantalizing clue, however, the kind that experimenters love. Gecko feet seem to get stickier on some surfaces than others. They are less sticky on low-energy surfaces like Teflon, and more sticky on surfaces made of polar molecules. This suggests that geckos are tapping directly into the molecular structure of the surfaces they walk on!

Tracking down this clue, Kellar Autumn of Lewis & Clark College in Portland, Oregon, and Robert Full of the University of California, Berkeley, took a closer look at gecko feet. Geckos have rows of tiny hairs called setae on the bottoms of their feet, like the bristles of some trendy toothbrush. When you look at these hairs under the microscope, the end of each seta is divided into 400 to 1000 fine projections called spatulae. There are about half a million of these setae on each foot, each only one-tenth the diameter of a human hair.

Defying gravity. This gecko lizard is able to climb walls and walk upside down across ceilings. Learning how geckos do this is a fascinating bit of experimental science.

Autumn and Full put together an interdisciplinary team of scientists and set out to measure the force produced by a single seta. To do this, they had to overcome two significant experimental challenges:

Isolating a single seta. No one had ever isolated a single seta before. They succeeded in doing this by surgically plucking a hair from a gecko foot under a microscope and bonding the hair onto a microprobe. The microprobe was fitted into a specially designed micromanipulator that can move the mounted hair in various ways.

Measuring a very small force. Previous research had shown that if you pull on a whole gecko, the adhesive force sticking each of the gecko's feet to the wall is about 10 Newtons (N), which is like supporting 1 kg. Because each foot has half a million setae, this predicts that a single seta would produce about 20 microNewtons of force. That's a very tiny amount to measure. To attempt the measurement, Autumn and Full recruited a mechanical engineer from Stanford, Thomas Kenny. Kenny is an expert at building instruments that can measure forces at the atomic level.