After the Fact | Scientists at Work: Why Do Mosquitoes Bite You?

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TRANSCRIPT

[Sound of mosquito buzzing and insect spray]

Dan LeDuc, host: Have you ever been at a summer picnic and just been convinced that mosquitoes really like you, and you go home with all the bites to prove it? Turns out there's a bit of truth to that.

[Intro music]

Dan LeDuc: Welcome to "After the Fact" from The Pew Charitable Trusts. I'm your host, Dan LeDuc. In this latest installment of our "Scientists at Work" series, we are talking with Pew biomedical scholar Lindy McBride, who researches mosquitoes at Princeton University. Our data point for this episode: 100 million. That's the number of people infected each year by mosquito-borne diseases, and Lindy says the actual number is likely much higher. She studies mosquitoes to see who they choose to bite—and how we can try to stop them—and reduce the spread of disease.

[Music transition]

Dan LeDuc: So when we're at a picnic and we're slapping our arms, we wonder like why are mosquitoes even on Earth? What is their purpose?

Lindy McBride, 2015 Pew biomedical scholar and assistant professor in Princeton University's Department of Ecology and Evolutionary Biology: That's a great question. Personally, I think the purpose of most animals is just to survive, right? Their goal is to find food and reproduce. But in terms of what they might do to benefit us, a lot of people don't realize that mosquitoes are actually pollinators, particularly male mosquitoes. Male mosquitoes do not bite. But they do need nectar in order to fly around and have energy to live. So they are a significant source of pollination.

I think even more importantly, mosquitoes are very abundant and they're a critical link in the food chain. They provide food for bats and birds and fish, a lot of things that we love and care about. And, so, if we did not have mosquitoes, we would probably not have a lot of those other things as well.

Dan LeDuc: So why do mosquitoes seem to prefer some people over others? We hear that. Is it anecdotal, or is that, in fact, true?

Lindy McBride: That is very true. Mosquitoes definitely have preferences. They like some people better than other people. However, when I tell people that I study mosquitoes, every single time the very first comment someone will make is that oh, I am so much more attractive than my spouse or my friend, or I'm so much less attractive. Why do I always get bitten so much? Or why do they love me? And, interestingly, our perception of how attractive we are does not often reflect reality.

Dan LeDuc: Well, isn't that true in so many ways?

Lindy McBride: Yes, that is true. That is definitely true in a lot of different aspects of life. In this case, how you perceive yourself in terms of how attractive you are to mosquitoes is really largely driven by how strongly you react to mosquito bites.

In an extreme case, someone who simply does not react to mosquito bites, and those people do exist, that person will never know they're getting bitten. And they'll think that they're very unattractive. And at the other extreme, someone who reacts very strongly will remember every bite. So that's what I always tell people when they talk about that. At the same time, there are differences, true differences, in how attractive we are to mosquitoes. And that's driven largely by our variation in the way we smell.

Dan LeDuc: And that's just because people are—one person is different from another?

Lindy McBride: Yeah, people vary in everything, including the particulars of their body odor.

Dan LeDuc: Mosquitoes are more than an annoyance. There's more than 100 million people a year who get diseases. I mean, some really nasty diseases from mosquito bites. How does that weigh on you as you do your research?

Lindy McBride: Yeah, it is definitely there in our minds when we do this research. We care a lot about that. And we hope that our work can have an impact on mosquito-borne disease. It's true that in this country, mosquitoes are largely a nuisance in most places, something that we want to keep away from our Labor Day picnics and things like that.

But in many parts of the world, it's a life-or-death situation. And mosquito-borne disease disproportionately affects the developing world, the tropics, and subtropics. That's where these human-specialized mosquitoes live. There are over 3,000 species of mosquitoes worldwide and only a handful truly specialize in biting humans. But it's that

handful that are the most dangerous to us. So this includes a species called *Anopheles gambiae*. It's the African malaria mosquito.

And it's been traditionally responsible for most malaria cases in Africa. Although, that's changing now. The other species, the one that we study in my lab, is called *Aedes aegypti*, and that's the yellow fever mosquito. But in addition to yellow fever, it also carries dengue fever, Zika, chikungunya. And those diseases—those are probably the mosquito-borne diseases that people have most heard about.

These other mosquito-borne diseases that aren't as likely to kill you, like dengue, they infect hundreds of millions of people a year. And they lead to lost work, missed job opportunities, general agony and suffering. I've never had dengue myself. But, apparently, it's an experience one is unlikely to forget.

Dan LeDuc: So let's talk about how concerned we should be if we're out and about at a picnic and the mosquitoes are there and light on our arm, recognizing that the ones that like to bite us are the ones that are really, really can be bad for us. How—I mean, is it not just an annoyance? Is this a real health concern people should be thinking about at their picnics?

Lindy McBride: It depends where your picnic is.

Dan LeDuc: OK.

Lindy McBride: If you are in the southern U.S., say in Florida, for example, where the dengue yellow fever mosquito exists, it is something to think about. As we saw with the recent emergence of Zika, there were cases in Miami and other places in Florida.

In most of the U.S., the major mosquito-borne disease is West Nile virus, which is actually a bird virus that's passed to humans by mosquitoes that primarily like to bite birds but will sometimes also bite a human. And that virus is not nearly as dangerous as many others. But it can still be dangerous to people with suppressed immune systems or the elderly. So it really depends who you are and where you are.

Interestingly, it seems like one of the most important drivers of this evolutionary shift to humans was the way that we manipulate water. Mosquitoes need water to lay eggs. They lay eggs in water, and their larvae actually swim around and eat bacteria and to try to—so that is a critical part of their life cycle. They have to find water.

So the African malaria mosquito often takes advantage of irrigation ditches and lays eggs in water that's used, like, in rice fields and things like that. The other species that we study, the dengue mosquito, that takes advantage of buckets and flower pots and

old tires. It lays in artificial, like, human-made containers that collect rainwater. And so we think actually it's nothing about our blood or how big we are or how hairless we are. It's probably actually our manipulation, the way that we manipulate water and we make it available to mosquitoes even in the dry season that was the initial push to get them to specialize in biting us.

Dan LeDuc: So we sort of caused this at one point in history?

Lindy McBride: In a way, we did, yeah.

Dan LeDuc: So how did we—how did you learn this stuff, why they like to bite us, what is it about them?

Lindy McBride: They're looking for a particular blend of compounds that's characterized as human odor. And they've evolved a way to recognize that blend and be very sensitive to it and to use it as a cue to find us.

Dan LeDuc: It's basically how we smell.

Lindy McBride: Yes.

Dan LeDuc: So, and let's make it clear for everybody listening. We're not talking about, like, OK, you've been out exercising. You're perspiring. All of us need a shower at that point. We could have been walking out first thing in the morning, freshly showered, ready and groomed for the day, and they're still going to come after us?

Lindy McBride: Absolutely, we do these experiments in the lab where we have 100 female mosquitoes in a box. And we blow human odor through the box. And the human odor is coming from someone's arm. They just stick their arm in this little tube and the air blows over their arm, picks up their odor, and takes it to the mosquitoes. The mosquitoes can't actually reach the human to bite. They can just smell them. And I can shower, walk to work, walk into our behavior room, put my arm in that thing, and 95 of 100 mosquitoes will fly towards my arm.

Dan LeDuc: Wow, so let's be clear, too. You get to be the lucky one who sticks your arm in there.

Lindy McBride: I do, also my graduate students and postdocs. During these experiments, we don't get bit.

Dan LeDuc: OK.

Lindy McBride: We're just trying to isolate or study how the mosquitoes respond to our odor, not actually how they bite us.

Dan LeDuc: So, I mean, we talk about mosquito noses. How do they actually smell? How do they—so you're actually studying mosquito brains. You must have an incredible microscope.

Lindy McBride: Yeah, it's really fascinating. Mosquitoes smell things a lot like humans do. So they're volatile molecules in the air. And they end up on their antenna. And they have little hairs on their antenna that are hollow that house neurons that sense these odors so that the odor diffuses into the hair and is recognized by a receptor in one of those neurons. Then the neuron will fire and send a signal to the brain.

And they have hundreds of these neurons on their antennae. And once it gets to the brain, there's this area that's called the antennal lobe. And all the information sort of converges on this one place in the brain. And so what we do is we've created transgenic mosquitoes that express a sensor in those neurons in that one place in the brain. And what that sensor does is when the neurons fire, the sensor becomes fluorescent. And so we can cut a little window in the head of a mosquito and put it under a big, fancy microscope and we can watch their brain as we're exposing them to different odors. And we can see these neurons light up.

Dan LeDuc: That's fascinating. I'm thinking about the size of a mosquito. So how do you do that?

Lindy McBride: It is quite difficult and it's been done for a long time in fruit flies, the model system.

Dan LeDuc: So how did you get started in all of this? Did you start with mosquitoes back when you were like an undergraduate going, I'm tired of being bitten, and I want to know why? Or was there something else that happened?

Lindy McBride: No, at first, I was really interested in just evolution in general. And so the thing that we care about a lot with these mosquitoes is how they've evolved to do this. And I always just loved being outside and looking at animals and plants. And I wanted to be kind of in the wilderness, doing fieldwork like a field biologist.

So I started with birds, studying bird songs. And I always laugh about this with my partner because when we met, I was on my way to Africa to study bird songs for a year in Tanzania. And she said that was very adventurous and romantic and came with me. And we sort of fell in love there. And then we came back to the States. And I started graduate school. And I started studying butterflies, and that was like a step down. It's

definitely not a bird. But they're still pretty, and I was still in the mountains in California studying butterflies. And then from there, I went to mosquitoes. And she always jokes that if I go to cockroaches, then the relationship is over.

Dan LeDuc: Yeah, I was going to say, this is not a good trend line for you.

Lindy McBride: That's right. It's not good. But I think we're going to stick with mosquitoes. So, hopefully, my family is safe.

Dan LeDuc: So what are some of the lessons that you look for? What are the lessons of evolution? And how have all of that—how has all of this changed?

Lindy McBride: I think we can understand some fundamental principles about brain evolution by looking at simple things like mosquitoes. So how does—how did the neurons in the neural circuit that detect odor, how did that change? Do we have new neurons being born? Do we have new connections being made? Or do you just have the same basic circuit with different sensitivities? Maybe the neurons are a little more sensitive, or they're more likely to transmit a signal.

I also think that by understanding exactly how these mosquitoes evolved to prefer humans and to love humans so much, that will tell us what they're looking for in our odor. And that could help us design repellents to prevent mosquitoes from biting us, which is particularly important, of course, if you live in a place where there's a lot of mosquito-borne disease, and also attractants so that we can pull mosquitoes into lethal traps.

Dan LeDuc: So when we talk about repellents, because that's something I wanted to get to ask you about, because all of this gets back to, like, odor, they have to be very specific. We can't just, like, mask human odor with cologne or perfume. It's something more basic than that that's going on that you're trying to get at.

Lindy McBride: Yeah, it's very difficult, as most people will know from their own experience, to stop mosquitoes from smelling you. Perfume doesn't work. I mean, there's a couple products that people think might make you less attractive to mosquitoes. But it's very difficult.

Mosquitoes are so good at recognizing the specific blend of compounds that we give off. It's very difficult to add a single compound that they don't like and prevent them from finding us. I think what's more effective is we need to find a way—and this is actually what some people think DEET does—we need to find a way to kind of prevent them from smelling us in the first place, to interfere with their ability to recognize that blend.

Dan LeDuc: As you move forward with mosquitoes, what do you want to learn? What are the lessons that you sort of think are out there that you're looking for?

Lindy McBride: I want to know exactly how these mosquitoes have evolved to recognize the way we smell. I want to know how their brain has changed. I want to know what parts of human odor they're cuing in on.

And I want to know—another question we're really interested in—is why in the first place they evolved to do this. Why do they love humans so much? Why is it good to bite humans?

Dan LeDuc: Is it fun to go to your lab every day?

Lindy McBride: Yeah, I love it. I love what we do. It's really interesting.

Dan LeDuc: You started with birds and audio. And we all want to relax to the sound of birds. But you found your Zen here with your mosquitoes.

Lindy McBride: Yeah, I guess I did. I love rearing things. I like taking care of animals. There's something about—some people think the most tedious part of what we do is just raising mosquitoes. But I actually quite like it. Something about taking care of something and seeing it become a nice healthy organism is satisfying.

Dan LeDuc: Lindy McBride, thank you so much. This is fascinating.

Lindy McBride: Yeah, thanks so much. It was really fun talking.

[Transition music]

Dan LeDuc: To learn more about Lindy McBride's research and other Pew biomedical scholars, visit pewtrusts.org/afterthefact. And if you like what you're hearing, tune in for new episodes of "After the Fact" on Apple Podcasts, Stitcher, Google Podcasts, Pandora, Spotify, or wherever you listen. Thanks for joining us.

[(Female voice over closing music) "After the Fact" is produced by The Pew Charitable Trusts.]