TRANSCRIPT

Key Conversations with Phi Beta Kappa

Exploring the Evolution of Animal Weapons and How it Relates to Arms Races in Military Technologies with Professor Doug Emlen

In this episode, evolutionary biologist Douglas Emlen joins Fred Lawrence in a conversation about his research on extreme animal weapons— from the horns of a rhinoceros beetle to elk antlers. He discusses his family's scientific legacy, his early reluctance to follow in their footsteps, and how his childhood experiences in Kenya influenced his path. In his award-winning book, *Animal Weapons: The Evolution of Battle,* Emlen also explores the parallels between animal and human arms races. His interdisciplinary work connects biological evolution with military history, shedding light on the forces that drive the escalation of weapons in both human societies and nature.

Fred Lawrence: This podcast episode was generously funded by two anonymous donors. If you would like to support the podcast in similar ways, please contact Hadley Kelly at hkelly@pbk.org. Thanks for listening.

Hello and welcome to Key Conversations with Phi Beta Kappa. I'm Fred Lawrence, Secretary and CEO of the Phi Beta Kappa Society. Since 2018, we have welcomed leading thinkers, visionaries, and artists to our podcast. These individuals have shaped our collective understanding of some of today's most pressing and consequential matters, in addition to sharing stories with us about their scholarly and personal journeys. Many of our guests are Phi Beta Kappa Visiting Scholars who travel the country to our Phi Beta Kappa chapters, where they spend two days on campus and

present free public lectures. We invite you to attend. For more information about Visiting Scholars' lectures, please visit pbk.org.

Today I'm excited to welcome Professor Douglas Emlen. Professor Emlen is a Montana Regents Professor of Biology at the University of Montana, where he studies extreme animal weapons, including antlers and especially the outlandish horns of Rhinoceros beetles. His first book, *Animal Weapons: The Evolution of Battle*, compares arms races in animal weapons to those that occur in manufactured military weapons technologies, and was awarded the Phi Beta Kappa Science Book Prize in 2015. Professor Emlen's research has been featured in outlets including the New York Times, National Public Radio's Fresh Air and Science Friday, and YouTube's SciShow and MeatEater. He recently starred in documentaries about his work for the BBC, Nature's Wildest Weapons, and NOVA, Extreme Animal Weapons. Welcome, Professor.

Doug Emlen: Thank you. It's a pleasure to be here.

Fred Lawrence: I certainly want to have a chance to talk to you about animal weapons, to say nothing of rhinoceros beetles, but normally I would start now with your childhood, but I actually want to go back in your case before your childhood. You are the son and grandson of scientists. Your grandfather, John T. Emlen, was a distinguished biologist at the University of Wisconsin-Madison who studied animal behavior and arguably revolutionized the entire field. In fact, you gave the John T. Emlen lecture at Wisconsin-Madison back in 2005. So what was his influence on you, including maybe long before you were born?

Doug Emlen: You did your homework. I'm impressed. Yes. So my childhood was a little unusual in that sense that both my father and my grandfather were practicing biologists, and that had a huge impact on me. My grandfather was very Quaker in a lot of his philosophies, and so he was a mentor to young scientists and students that was very hands-off. He worked very closely with students, he helped them in all aspects of their research, but it wasn't about him or about his name. He often wasn't an author on the papers, and very often people never even realized that he was the professor behind the scenes, and I loved that aspect of mentoring, the explicit focus on the development of the mind of the student that you're working with. I think that rubbed off on my father and I like to think that it also rubbed off on me. I feel very fortunate to have gotten to know him while he was still alive.

Fred Lawrence: Do you remember a point when you thought to yourself that I want to follow this path? A lot of young people with a prominent father and grandfather in a particular field would say, "That's the last thing I want to do. I want to find my own path, and I'm not going to do that no matter what."

Doug Emlen: So backstory there, I mean that definitely was how I felt at first. And so the other piece that's missing here is that my father also is an evolutionary biologist or an animal

behavior biologist, and he was at Cornell, and so I was growing up in that town, and I ended up going to Cornell as an undergraduate. You're right, at that point, the last thing I wanted to do was go right back into biology. But I had inadvertently fallen in love with so many aspects of being a scientist that I think it sort of infused a lot of who I was. A lot of the science, I mean we sort of imprint on the macho Lara Croft or Indiana Jones stomping into wild adventures and crazy places, but a lot of the thrill of science is the intellectual game, it's the detective work. How do you ask your questions in just the right way to try to trick the animals into telling you in a sense, to reveal why they do what they do?

I was never the fastest athlete on the team. I was pretty much a nerd growing up. But those kinds of games that who can outsmart the system and figure out how to ask the question in just the right way, that was something I loved. And so I thought, all right, I'm not going to be a biologist, I'm going to go into archeology. I've always loved archeology. I love paleontology too. I love the deep past. So I used to find arrowheads in the tobacco fields across from my mother's farm in Tennessee, and you could pick up one of these things and you'd be that first person to touch that since the person who made it six or seven thousand years ago. I used to get a palpable rush from that sort of touching the past. And so when I started as an undergraduate, I thought, I'm going to be an archeologist.

I can do all the same macho field biology, get out into the crazy places and live in the tropics or wherever, working on a dig, and I'll be asking and answering questions based on human history and the clues that are left behind in archeological sites. So I started off on my own branch, but very quickly, you can chalk it up to teachers good and bad, but the professors at the time just killed it for me, and just the more I learned about it, the less excited I got, and at the same time, I kept coming back to biology, biology, biology, and so halfway through my undergrad years, it's like, all right, I really need to study biology. And then I was stuck. I was at Cornell, so I had to take my dad's classes, and that was a very memorable moment. I was sitting in the room with a big animal behavior, so 200 something students in this lecture hall, and there's my dad teaching the class at the front of the room, and I'm hiding in the back, nondescript, hoping nobody will notice.

Fred Lawrence: So what was that like? Emlen is not that common a name, so it must have been a fair question to ask.

Doug Emlen: So first of all, I was not the world's best student at that stage in my life. I had a lot of growing up to do. So I was out late at night partying with friends and things like that. I'm sitting in the back of the room probably hungover if I'm being honest, it was a long time ago, but trying to be nondescript and hide. And he completely called me out on the first day of class. I mean, he just points to the back of the room. He's like, "Let's just lay this out there. That's my son." It gets worse. He's like, "Look, we're going to talk

about a lot of things this semester related to animal behavior, and a lot of that has to do with kin selection and nepotism and helping relatives." He's like, "It's not going to happen." So he said, day one, he's like, "I give you permission to check on the grades at any point in this semester, and I give you my word, for the same amount of work, his grade will be lower." So I'm sitting there in the back of the room like, "Oh my God. He called me out. The whole class knows, and now he's going to be super hard on me."

Fred Lawrence: Look, let's stay in your childhood just a little bit longer. Tell me about your childhood experiences growing up in Kenya.

Doug Emlen: My dad at the time was studying cooperative breeding behavior in a bird called the white-fronted bee-eater, and so he had a crew of graduate students and research techs and people over in Kenya. So by that point, family history, my parents had separated and remarried, and so my sister and I were going back and forth between East Tennessee part-time with our mom and Ithaca, New York part-time with my dad, so in a way he could go do the field work at the times of the year when my sister and I were with our mom, and that gave him quite a bit of flexibility. But he tried to arrange it so that we would have a chance to come and spend significant time with him in Africa while he was doing field work. And so we went to Kenya for about six months and had to pull out of the school system and then get embedded into one of the boarding schools.

It was called Greensteds School outside of Nakuru, Kenya. And so my sister and I would go to the boarding school and live at the school for the week and then come home to the place that they were staying in Nakuru National Park on the weekends. For six months we got completely immersed into everything: culture, history, the British school system in a Kenya country, and then all the people and the places and the animals living inside a national park in Africa. And it was incredible because we really lived in the park. They had a house that was a carryover from before the park had been made a park, and they let researchers from Europe or from the United States live in there while they conducted the research. So we got to do it all, climbing down into the river basins and helping him trap and band the birds and put the tags on and learning how to do insect censuses or work through spotting scopes and binoculars to track who's interacting with who.

That was almost certainly part of why I imprinted on the lifestyle of a biologist, just the smells, the peoples, the cultures, the languages, not being a tourist and going on vacation for five days in a hotel, but actually living somewhere and learning about the place and the people and the history, and then of course the biology because we were there inside a national park learning about biology. That was pretty transformative for both me and my sister, and then I got to go back a second time in high school to spend another month with him much more explicitly working on the project full time.

Fred Lawrence: You can't fake what you're passionate about. So do you have a memory of a time when you genuinely didn't know whether you wanted to be an academic, or did you always think this was kind of the path?

Doug Emlen: I think I always thought this was going to be the path. Like I said, I initially thought I was going to be a different kind of academic, sort of asking different types of detective problem solving questions in archeology and even this late in my career doing what I do, there's still a side of me that's just obsessed with fossils. Montana happens to be an incredible place for fossils, and so when I get all burned out and done from a semester of teaching 240 students and I'm ready to let off steam, I drive nine hours to the middle of nowhere, sleep on the ground by the side of my car and just hike mile after mile looking at the ground and looking for fossils. And so maybe I should have been a paleontologist, but I always knew that I was going to be some kind of an academic scholar within a university system. I'm a little bit unusual that way, but it's just that's how I was raised.

Fred Lawrence: So let's talk about some of the projects that have caught your attention and have brought you into the world of scholarship and therefore brought it to all of our attention, your particular interest in animal weapons. Your book, *Animal Weapons: The Evolution of Battle*, won our Phi Beta Kappa Award for Science in 2015. So let me ask you first how the book came to be and tell us a little bit about the fieldwork that was involved in that book.

Doug Emlen: I had to put my finger on the thing that really got me tossing and turning at night trying to solve the problem, trying to figure it out. It's like, how are things like this possible? I really am drawn to the extremes in nature where you look at these animals, I mean, if you came from another planet and you looked at a bull elk or you looked at a rhinoceros beetle with the horns coming off the head, I mean, a rational person would look at that and say, "That shouldn't work. That shouldn't be possible. How can you have 40 pounds of bone extending up and off the top of the head of these males?" And the example I like to use with the rhinoceros beetles, I mean, we think of antlers as huge, especially if you live where I live and you see elk all the time, but even the biggest antlers in the largest bull elk are probably only about 5% of the body weight of that bull. But when you start talking about the horns on a rhinoceros beetle, they can be 30% of the weight of the male.

I mean, how do you imagine it? The example I like to use is literally in terms of proportion, like you having a coffee table fused to the top of your head and going about all of your adult life with that thing stuck to the top of your head. How does that work? How is it possible? So yes, I study weapons, but I study weapons because they're an extreme. They're a type of trait in animals that in some particular species gets caught up in a feedback cycle, an arms race basically where bigger and bigger and

bigger and bigger selection can push the evolution of these things to the limits of the possible, and so I've been able to look at that kind of a problem in a lot of ways.

We spent a lot of years looking at the genetics, the types of developmental pathways that build a weapon like a beetle horn. It turns out it's the same genes in the same pathway that build antlers and build tusks. All of these extreme structures are built using the same types of developmental processes and gene networks, which I think is pretty cool. I was interested in the functional significance of these things. Why are they so big? What are they doing with them? So I spent a career studying extreme structures in beetles. All the while, I was reading about other examples, compiling papers and stashing them on elk antlers and tusks, and I love fossils, so all the extinct things like triceratops horns and titanothere and brontothere knobs and horns, crab claws. I mean, there are so many examples of these extreme weapons, and I kept pulling all these things aside. Then finally I sat down for one year and it's like, I really need to pour through this literature and see what kind of common patterns there are.

I'd been invited to write a review article for a journal called The Annual Review of Ecology and Systematics, and I thought, all right, this is the moment. And I laid out all these papers and I started reading through them, and my goal was to try to synthesize what we know about all of these types of extreme weapons. The more I did that, the more I realized there's a lot of story here, there's a lot of stuff to tell, and it's a really common theme. It doesn't matter if I'm talking about eyestalks on a fly that lives in New Guinea or I'm talking about crab claws or I'm talking about tusks in a mammoth or a mastodon or horns in a rhinoceros beetle, it's really the same story. But at the end of the day, the whole goal with writing that book was to try to tell the stories of these animals with these incredible extreme structures and do it in a way where that sort of common central theme showed through, shined through.

Fred Lawrence: So we've been talking about the animals and their attributes and the study of animals, but you've been involved in addition with remarkably interdisciplinary work about not just arms races among the other members of the animal kingdom, but the human members of the animal kingdom. One of your lectures as a Phi Beta Kappa Visiting Scholar, Extreme Weapons in Natural History, deals with this by looking at weapons manufactured by humans and as well as extreme weapons in animals. Two questions really. How did this connection come about, and then how do you see these connections or how do you explain the interdisciplinary?

Doug Emlen: I'm really glad you asked me because this is another big surprise. This is not something that I sought or I planned or I anticipated at all. It actually came from working with editors trying to write that book, the same story we were talking about. How do you engage an audience? You said, "How do you tell all these stories and not have it feel dry and technical?" Well, one of the things that my editor suggested is, "Why not talk about military technologies too?" Because it was really apparent even on the surface

that there's a lot of things that superficially are very analogous or very parallel. And at first I was like, "No, no, no, no, no. I'm a biologist. I'm writing a book on biology. I'm not qualified to write about that." But she kept saying, "Yeah, I think you should look into that. I think you should look at that."

And then finally, I did it. I started poking around a little bit. I read a lot of history anyway, just because I love history. But now I started reading this through a different lens. I wasn't just reading to learn about World War II. Now I was reading like a scholar, saying, well, wait a minute, how does it work and why does it work that way? And it turns out there are military historians who thought about the same questions that I was thinking about. Why does an arms race begin? When does it begin? When it begins, what happens? How does it unfold? And so the more I started looking, the more I got sucked into that rabbit hole because it's like, oh my God, it's really similar. And so initially it started out just as a couple anecdotes so that I could try to make the material of the biology of the animal weapons a little bit more relevant or a little bit more interesting to non-biology audiences. But it grew into something a whole lot more.

Part of that is an editor decision, editor author back and forth, and part of it is a scholar, it's a research thing. So the editor one, at first I was like, "Whoa, whoa, whoa, they're not the same." So it's like, I'm going to tell all the biology stories and then a line in the sand. I'm going to have a chapter about biological evolution, cultural evolution, what you can, what you can't compare, and then we'll talk about the weapons at the end, the military stuff. She's like, "No, no, no, not a chance in hell. We want this stuff early." So it's like, okay, well, now I'll have a chapter on biology like crabs or something, and then I'll have a box. So there'll be the biology narrative, but then I'm going to set it aside, like visually it's set aside, here's a box, and then I'll have the military parallel, and then at the end of the book, I'll tie them all together. And she's like, "No."

And by the end, not only had I got more comfortable with the writing back and forth, but I had done enough reading and scholarship in this to become absolutely convinced that they're not different stories. It's not a superficial parallel where you need a line in the sand. It's the same story. And so I went through this transformation realizing, oh my God, it's really similar. It's really, really, really similar. Wow, that's parallel, that's parallel, that's parallel, at the same time that I was researching and writing the book. So by the end of the book, it's like back and forth, back and forth, and it's just as much about military technologies as it is about biology.

Fred Lawrence: Well, it turns out that knowledge is not disciplinary. We're disciplinary, knowledge is not disciplinary, and when you look into something at a certain point, you put boundaries around what your project is because life is finite, not because there aren't more connections and more connections and more connections. If you had enough time in the world, all of it would connect to all of it, I suppose. But in the meantime,

the connection between our animal colleagues, our non-human animal colleagues and our fellow humans are fascinating.

One of the things we do on Key Conversations, as I think you know, is help our listeners build their reading lists. We like to think that at Phi Beta Kappa, if we can provide the curriculum for continuing lifelong learning in the liberal arts and sciences, we've done a service to our listeners. So I wonder if you can help us with that. What are a couple of works that you would recommend either particularly in the evolutionary biology topics we've been talking about, or to go back to something else we've talked about: really good science writing that is serious, robust scientific analysis, but at the same time is accessible to a serious general reader, not just to a specialist in the field?

Doug Emlen: Yeah, that's really where I want to dig in, and again, I want to make the point that by trying to write myself, I look at the process of science writing completely differently than I used to, and I'm much more cognizant of the challenges and the art form. I think that when science writers really get that right, when they figure out how to tell the narrative story with a voice that is authentic, that's believable, and that has sort of an arc to it that logically assembles the pieces of the biology in a way that makes it effortless for the readers to read, I think you can get some real masterpieces. I think these authors are able to reach both lay or non-academic audiences and technical audiences at the same time by threading that needle perfectly. And I guess if I get to pick a couple of my favorites-

Fred Lawrence: Please.

Doug Emlen: I have had the privilege of working with Carl Zimmer. We co-author a textbook on evolutionary biology together for more than a decade, and I think he is a breathtakingly good writer. I love working with him on this textbook, but he spends most of his time writing for the New York Times and writing books, and his book, *She Has Her Mother's Laugh*, does a brilliant job of blending sort of the history and the backstory of how we learn, what we learn about heredity with a very current view of how genes work and how characteristics get passed from parents to offspring. It's this fundamental tenet of biology that's actually really complicated when you start putting in all the new facets of genomics and epigenetics, and I think it takes a master science writer to really tell that story well, and I think Carl Zimmer does that beautifully in his book, *She Has Her Mother's Laugh*. I also think Siddhartha Mukherjee has a book called *The Gene* that does a brilliant job at that also.

Fred Lawrence: You will be pleased to know he is a fellow winner of the Phi Beta Kappa Science Book Prize for that work. He received that award several years ago at one of our book award dinners, and has, I agree with you, has written a masterful serious scientific work, but highly engaging and written beautifully for the general audience.

Doug Emlen: I had not done my homework. I'd forgotten that. I did not know that in advance, but awesome. I think a topic that resonates with a lot of people is cancer. Cancer is something that's medically scary, very relevant. Most of us know people that have battled with it or are battling with it. It's also an area where evolutionary biology, my field, has a lot to say both about understanding where it comes from, how it works, and also thinking about radical and innovative ways of fighting cancer, and I think that's another one where there's history, there's very complicated biology, and it's difficult, it's a hard topic emotionally because we all care about it so much. And there's a few. So Athena Aktipis, her book, *The Cheating Cell*, does a wonderful job of this. And again, back to Siddhartha Mukherjee, *The Emperor of All Maladies*, does a really good job digging into this. It's scary, it's a heavy book, but it's a brilliant book.

Fred Lawrence: Doug, they say that the through line of all great teachers, regardless of field or method of teaching, is an enthusiasm for the topic, and you certainly have shared with us your remarkable, contagious, if I might, enthusiasm for the topic. We're delighted to have you as a Phi Beta Kappa Science Prize Book winner. We're delighted to have you as a Visiting Scholar, and it's been a pleasure to have you with me today on Key Conversations with Phi Beta Kappa.

This podcast is produced by Phantom Center Media and Entertainment. Kojin Tashiro is lead producer and mixed this episode. Michelle Baker is editor and co-producer. Hadley Kelly is the Phi Beta Kappa producer on the show. Our theme song is Back to Back by Yan Perchuk. To learn more about the work of the Phi Beta Kappa Society and our visiting scholar program, please visit PBK.org. Thanks for listening. I'm Fred Lawrence. Until next time.

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