TRANSCRIPT

Key Conversations with Phi Beta Kappa

From Dinosaurs to Birds: The Science and Language of Evolution with Dr. Julia Clarke

For Professor Julia Clarke, paleontology is more than just a passion for exploration and discovery — it's a shared, global dialogue that has the ability to permeate cultural differences. In this episode, Dr. Clarke recounts how her early interest in the history and philosophy of science merged with her desire to have a practice deeply woven into narrative. As a professor and researcher, she prioritizes the questions that guide a discipline into a new area, calling it "a fundamental part of science". Giving both in-depth and thought inspiring lectures such as "The Secret Lives of Dinosaurs," Dr. Clarke dives into the origins that led her into the world of geobiology, the importance of staying curious and learning to communicate through the language of science.

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 delighted to welcome Professor Julia Clarke. Julia Clarke holds the Jackson Chair in Geobiology and is the associate Dean for Strategic Education and Research Impact at the Jackson School of Geosciences at the University of Texas at Austin. She has an international field

program in paleontology and leads highly interdisciplinary collaborative teams integrating data on living animals to ask new questions about the fossil record. Her research has been funded by the National Science Foundation, the National Geographic Society, AAAS, and Howard Hughes Medical Institute among many others, and has been covered by NPR's Science Friday, the New York Times, Washington Post, NOVA, and many other outlets. She's a fellow of the World Society of Biology, the American Ornithological Society, and the Anatomical Society. Welcome professor.

Julia Clarke: Oh, I'm so happy to be here.

Fred Lawrence: Everyone, it seems to me, loves dinosaurs, but you somehow have managed to take what for many of us, certainly for me, was a childhood fascination and make it into a professional career in an area of deep study. But you got a bachelor's degree from Brown University and double majored in geology, biology, and comparative literature before your PhD at Yale in the Department of Geology and Geophysics. So I'm especially interested in that comparative literature background and how it fits within the whole picture.

Julia Clarke: Ever since I was a kid, I was interested in stories and narratives of exploration. I went to college thinking I wanted to study archeology. We get confused a lot. Archaeology is a study of remains of human cultures, and I thought that's what I wanted to do. So I started Brown and took my first archeology class, and I was profoundly struck by the stories that we tell about past human culture through artifacts. I wanted to separate my interest in objects as keys to a deep history from narrative or about human identities, and those are inexorably woven.

I'm very interested in the history and philosophy of science. I found that I kind of wanted to separate my practice to have a practice deeply embedded in narrative. I wanted to learn a foreign language above the level of competency I had in high school, because I knew I wanted to work globally. The other part of that was I really wanted to be versed in things that are about those natural objects that become part of our deep history - fossils - that involved learning about both geoscience and biology. So that's how I kind of arrived at this double major.

Fred Lawrence: So the interest in fossils is the entry point and the dinosaurs follow on from that?

Julia Clarke: Absolutely. I was interested in the work that you would do with these remains: skeletons, shells, all of these different kinds of relics of past life. I definitely was not super engaged with dinosaurs, specifically the geobiologists that I worked with at Brown, were paleoclimatologists. I also worked with a planetary geologist. I was learning things about the Earth's system following a passion for asking interesting questions about Earth's deep history.

Fred Lawrence: The great story told of the Nobel physicist Isidore Rabi, when he was asked, "When did you first become a scientist or what made you become a scientist?" He said that when he used to come home from school as a little boy, his mother would always ask him, "Did you ask a good question today?" She didn't ask him how well he'd done in school or if he'd done well on a test. She said, "Did you ask a good question today?" And he said, "I think that's when I became a scientist."

Julia Clarke: One of the things I really tried to imbue in both my teaching practice and my research practice, is it's the questions that we identify to ask that really guide a discipline into a new area. It is a

creative process to identify those new questions, and that's a fundamental part of science. I agree wholeheartedly.

Fred Lawrence: Now, the difference between archeology and human artifacts, which at most could take us back a couple 100,000 years if you mean early homo sapien experience, but what you're talking about with fossils, taking us back through dinosaurs, is by a huge degree of magnitude. I mean, the numbers are sort of mind-blowing, right? 65 million years ago, do I have that right, is when the dinosaurs roughly disappeared from the planet, we think?

Julia Clarke: Well, non-bird dinosaurs disappeared around 66 million years, but it is an unfathomably long time. So when we talk about dinosaur origins, we're talking about more than 200 million years. So it's just really hard for us to wrap our human brains around.

Fred Lawrence: So when you are talking to particularly entry level students or as a Phi Beta Kappa Visiting Scholar, if you're talking in a public lecture, thousands of years is hard enough, but one can somewhat think about thousands of years takes you back to the early Christian period or the early biblical period or a few thousand years beyond that, to Greece or Egypt. But now we're going more than thousands and now we're going into millions. Now we're going into tens of millions. How does one, even as you say, wrap your mind around what it means to be in a period that largely ends 66 million years ago and begins another 150 million more years than that?

Julia Clarke: Every time that I teach an entry level course, we do this project where we have big sheets of paper and we put these relative dates on this huge roll of paper, and the students are marking out this time, and I think they get a visceral sense of how long that pre-human period really is. But I think that oftentimes as a practitioner, you kind of become so used to working with these enormous timescales that you can say things that sound to the average person a little absurd. A geologic moment might be hundreds of thousands of years in a rock record. We might not be able to resolve in certain settings that time.

So we might not be able to see what's happening within that period, a 100,000 years, in a particular location. You get very used to these, oh yeah, it's only five million years and that's a short period of time. We think the average species duration is about 3.3 million years, is about the lifespan of a species. Someone calculated that back in the '80s, I believe. But we are dealing with things that are kind of on the bounds of what we as humans can really understand, like a mass extinction event. We've gotten more used to thinking about those things now in this cultural moment, but historically, those were almost unfathomable in their scope.

Fred Lawrence: You say the average lifespan as it were, of a species, excess of three million years. So we, homo sapiens, are really a very early experiment in that, aren't we?

Julia Clarke: Yeah, we're pretty young. There's just a lot of interesting stuff going on in human origins, and again, I don't work fundamentally in that time period, but I follow it, because it's quite interesting. You're getting that pushed back some with the 400,000 maybe for kind of interbreeding with Neanderthals. Again, this is not my area of focus. We would be in the early part of our history as a species. Some species don't get that 3.3 million. They go extinct earlier.

Fred Lawrence: Which is an alarming thought for homo sapiens, since I think we tend to think of this whole process as having been designed to arrive at us when in fact the process rather dramatically precedes us and let's at least say is bigger than us.

Julia Clarke: Absolutely. I think it's so important to remember we're just one species traveler in this world that is just filled with millions of others, and that's what I like in my public lecture is actually to leave people with, the thought that dinosaurs are still among us, as birds. They're in their backyards. There are these co-travelers over immense periods of earth history, other lineages of animals that have a separate history, but also one that's very much in the present moment intertwined with our own.

Fred Lawrence: So let's talk about those dinosaurs who are still among us. How did the birds evolve from dinosaurs and what was the role of avian flight in their survival and their evolution?

Julia Clarke: Yeah, it's a great question. It strikes me when I do give these public talks, how many people are still surprised by that notion, the notion that birds are living dinosaurs. On some level, we're fairly comfortable, I think, with the notion that humans are mammals. We all share traits that are present in all mammals, and similarly, birds are nested within this huge radiation of dinosaurs, just like there are many mammal species that are not around today. There are whole groups of amazing mammals that are not around today. What we have in the case of birds is that their one lineage that survived this mass extinction and gave rise to this incredible diversity we have today. A lot of people also don't realize that dinosaurs, if you will, are the most species-rich group of terrestrial vertebrates. They're almost twice as many living dinosaurs as there are mammals today.

So there's about, let's say 5,500 mammal species, but more than 10,000 species of birds. In terms of the fossil record, we have amazing fossils that preserve things like feathers and those feathers are present on skeletons of animals. We used to say, oh, well, that's a dinosaur. That's not a bird. But these are human dichotomies, and I think your audience as Phi Beta Kappa members are going to be very versed in thinking about language and how we as humans talk about life and divide it up. Evolution doesn't care what humans, how they want to divide things up. It's a lineage in which traits evolve, and we can see those traits often in the fossil record, and what they do is locate birds as one lineage within this amazing diversity that most people as kids have a period short or long a fascination with.

Fred Lawrence: How did the group of species that we call birds survive the mass extinction event that wiped out most of what lay people would call dinosaurs?

Julia Clarke: This is a question that I started thinking about at Brown when I was an undergraduate and still doesn't have an easy answer. The way I'd approach it for people to think about it, is that flight evolved way before the extinction event flight is present in the fossil record, right around 150 million years. The extinction event isn't until almost a 100 million years later. So it might be that flight is one trait, but it certainly isn't sufficient to explain survivorship. We know there are also metabolic changes, what we might think of as warm bloodedness. Those traits are about 200 million years old. So what you have then is those traits are not sufficient.

Some people have looked at body size, but the body size of these small flyers that went extinct is similar to the bodies of small flyers that survived. So some people then argued that the birds,

the relatives of living bird species were living in certain environments that were less impacted by the extinction event, but that doesn't fully explain it either, because you have survivorship in a whole bunch of different ecosystems as well as extinction. It's a complex question, but I think it's good for listeners to know that there's still open questions, because that's what attracted me to science back in the day, was the idea that we didn't have all the answers. Not having all the answers is as much a motivation to go into science as not thinking, well, science is going to have all the answers. So we're still working on that one would be a short answer.

Fred Lawrence: One of your Visiting Scholar lectures is called the Secret Lives of Dinosaurs, which includes gaining more insight into their color and into their sound. So tell us a little bit about that idea of the sound that dinosaurs made. I think many of us probably from popular culture have this image of them being particularly the large ones, very loud, rumbling animals when in fact, if I have it right, they made me think, sounds more like a pigeon.

Julia Clarke: Everyone translates that science a little differently.

Fred Lawrence: Okay. You tell me.

Julia Clarke: I would say you're mostly there. So what we historically have done is put the voices of large mammalian predators, lions and tigers and bears, they're larger than us, and we took their voices, in some cases, modified those voices, mixed in some elephant, and mixed in some other animals, and put them into the mouths of our movie dinosaurs. What we need to do is move away from a very different system that's present in those animals. They have a dynamic vocal tract, so you can see as I'm talking, I'm moving a lot of muscles in my face. I'm shaping my vocal tract, but dinosaurs don't have that same set of dynamic facial muscles of lips to shape sounds. So it's better for us to look to either living dinosaurs, that is birds, or to their closest cousins, crocodilians and those two groups as we published in a paper called Booms, Hoots, and Coos, maybe where you get the doves, because that science gave me a new appreciation of doves.

What we were looking at was the probability that some extinct dinosaurs also used closed mouth vocalization, which is essentially making complex sounds with the mouth closed. There's not a lot of capability there, but if you have a different sound maker and you have a way of involving either the mouth or in the case of doves, the esophagus, in shaping sound, then you can produce quite a different range. We weren't saying that T-Rex cooed, but that it could have similarly deployed its esophagus. So it is kind of crazy to think that the pigeons outside your window are blowing up their esophagus, closing their mouth, to make those lovely coo sounds.

But if a T-Rex was doing that, the frequency range would be much lower. So we have to think about really large-bodied animals that shape sound in that way, that are going to be much lower frequency sounds. In any case, this was revolutionary to look at sounds that have been put into the mouths of dinosaurs that were from crocodilians. When the crocodilians made those exact sounds, their mouth was closed. But in the movies, they're always about to eat a small child and the mouth is wide open. We can bring the science of sound making from living animals to the past, to make these animals, bring them to life, but in a much more, in a way informed by science rather than solely the realm of the imagination.

Fred Lawrence: How much are you drawing on the fossil record in this kind of research and how much are you drawing on animals that are alive today?

Julia Clarke: So in the case of the work on sound, we've approached it through various different kinds of fossil records, but the fossil direct evidence is going to be extremely limited. What I would call direct evidence would be fossilization of the support structure for the vocal folds themselves, the things that produce sound. I was fortunate to find the earliest evidence of that within Theropod dinosaurs some years ago now. We published that in 2016, but it still is pretty limited in terms of what we've been able to find that is evidence of the support structures for those vocal folds.

Fred Lawrence: Your field work has covered everything from Antarctica to China to Peru. How do you choose where to go and do you have a couple of interesting field work experiences to share with us?

Julia Clarke: Sure. I love working all around the world, and I want to be clear on this too, because I think this is a really important part of thinking about what paleontology is today. To me, what it is that draws me to this work is not just that passion for exploration and discovery that I had as a child, but the passion to sort of speak the same science language with people from different cultural contexts, different starting places, to have that shared passion across cultures, and I think in this contemporary moment, that kind of continued dialogue that is not centering all of the global conflicts, certainly impact where one does paleontology and where one does science and they should.

What I love about it is that science has been a way for me to get to know people and places from all around the world. We can speak to each other in this language that is motivated by passionate curiosity about past lives. I absolutely love that. Antarctica, even in Antarctica, there are scientists that have worked in the same regions from different countries, and so we often work on fossils collected by scientists from other countries. Antarctica is pretty unusual in that any country can work there and the fossils are in collections all around the globe. So if you want to bring those fossils into dialogue with each other, you work with people from Argentina, from Chile, from China, for that work.

Fred Lawrence: Let me ask you about another place where education in the early dinosaur period takes place. What I have in mind is the BBC series, Prehistoric Planet with David Attenborough, which uses computer generated imaging and live footage to present what seems to me as a lay person to be a compelling speculation as to what the world might have looked like during the age of dinosaurs. Is this a useful form of public education in your view?

Julia Clarke: I think it is. I will say that whatever inspires people to deepen their fascination and their commitment to the natural world, to the non-human world, is something that I would support. We have to find ways to bring things we're used to exhibiting towards other humans - compassion, empathy - and have those feelings for things that are not humans. I think that we're at a critical juncture where that is urgent. Even these programs that inspire wonder, they inspire curiosity, they inspire empathy with the tiny Dimetrodon. So all of those things can cultivate a stance towards nature, which is ultimately a good thing. We talk a lot in the national science education landscape about how to broaden participation in STEM. We've identified that as a national priority. Dinosaurs are a great draw, but there are a lot of other jobs studying the natural world that are also super cool and super interesting. Students know a lot less about those. They know about volcanologists because they study cool volcanoes and then dinosaurologists, paleontologists, but there's so many other cool science jobs, and so how do we get that word out in this broadening participation frame?

Fred Lawrence: One of the things that I like to ask my guests on Key Conversations is to help us build our book lists, build our curriculum, as it were. As you've said, this is a subject of general interest to so many people, so I'm sure we have some listeners who don't have great expertise in paleontology, but have enough interest in it. So I wonder if you have a recommendation for those people who would have general interest, but would like to learn more as well as something more advanced for those with some sufficient background in the field, but would like to go further?

Julia Clarke: Well, that is a great question, and I think this is a Phi Beta Kappa conversation. I belong to scientific honor societies too, but one of the reasons I was interested in being a Phi Beta Kappa Visiting Scholar was that I really believe in the value of learning across disciplines. And so, this question about what's on my bookshelf or what I would recommend, is really interesting, because as a scientist, I mostly choose to read about things that I don't know about, and this is something that's really characterized my career, is that I want in my down time to be reading things that can inform my perspective as a scientist, but are very different. So I read a whole book on eels. I read a book, *Why Fish Don't Exist*, which actually has quite a lot of what I'd call phylogenetics, which is part of what I do, figuring out evolutionary relationships, that's part of that book.

I thought it was quite intriguing, and it also talks about people obsessed with learning about the natural world in a very interesting way. In terms of paleontology books, I can go historically to what was inspirational to me. I loved Michael Novacek's *Dinosaurs of the Flaming Cliffs*. This book came out quite some time ago, but what I loved about it was the sense of this place filled with the opportunity for new discovery. I was like, wow, maybe someday I'll get to go to Mongolia, and I've now worked in Mongolia for nine different field seasons.

So for me that book was a joy to read. It was written quite some time ago. I also found, there's another book that is about the obsession with life on earth that was really kind of interesting, compelling to me was this jumping off place for a lot of hard questions about colonialism and science in some ways, but is also a really interesting read, which is called *Life List*, and it's one woman's quest to see the most species of birds on earth. I'm reading Ed Yong's book on sensory systems, *An Immense World*, right now, and it's interesting for me because I work on sensory systems, but that's not my primary area of interest, so I found that quite interesting to explore.

Fred Lawrence: We are so pleased to have you as a Phi Beta Kappa Visiting Scholar this year. I know that you have shown your students at UT Austin and all the students you've interacted with as a Phi Beta Kappa Visiting Scholar how the love of dinosaurs or interest in dinosaurs can be interesting in of itself, but also a path that takes them on into whole new worlds they haven't imagined. Thanks so much for bringing that energy and passion and devotion to all your students, including the ones you meet on our campuses, and thanks for joining me today on Key Conversations with Phi Beta Kappa.

Julia Clarke: I want to thank Phi Beta Kappa for giving me this incredible opportunity to visit all of these amazing campuses and interact with so many fantastic students, and thank you for having me here today.

Fred Lawrence: This podcast is produced by Phantom Center Media and Entertainment. Kojin Toshiro 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.

CITATION:

Lawrence, Fred, host. "From Dinosaurs to Birds: The Science and Language of Evolution with Dr. Julia Clarke" *Key Conversations with Phi Beta Kappa,* The Phi Beta Kappa Society, September 9, 2024. www.pbk.org.

Produced by: