

into army ant society. They are a true rogues' gallery of beetles, flies, mites, and myriad other creatures, ranging from commensals to parasites of the traveling ecosystem that is an army ant colony. An epilogue wraps it up, followed by a glossary, a list of the literature cited, and an index.

By design, the book is engagingly written and short, yet it will also be a valuable addition to the specialist's library. The text is jargon-free, with frequent expositions of relevant general concepts, such as phylogeny, levels of selection, and inclusive fitness. The book can be easily read and enjoyed by a non-specialist, but at the same time it provides a guide to the technical literature, with in-text citations to over 600 references. Gems of writing are sprinkled throughout, such as alliterative "pot-hole plugs" (single workers spanning gaps) and "attraction to action" (worker response to moving prey). Workers schlep prey, stop at roadside restaurants, and exhibit road rage. A particularly flashy myrmecophile becomes a "glitter bullet" and is likened to a human cannonball in a sparkly sequined costume. A new concept is introduced with this passage: "Who determines that the conditions are right for a colony to divide? Is it the queen who decides to lay an extraordinary batch of eggs, or is it the workers who decide to raise an extraordinary cohort of larvae?" Such an elegant and simple way to state a basic question. When pondering the impact of myrmecophiles on army ants, Kronauer contrasts the number of ant workers per myrmecophile (5,000) with the number of humans per rat in New York City (4), citing a study titled 'Does New York City really have as many rats as people?' Brilliant. The text swings easily between general ideas and natural history details, and between existing knowledge and the author's own field observations. We can learn about the general distinction of migratory versus nomadic behavior, and also that army ants carry their larvae slung beneath them, head forward, and mouth up (who knew!?). The illustrations, making up nearly half of the book, are mostly large color photos taken by Kronauer, and as I read the book I found myself eagerly seeking out the images that accompanied textual explanations. I know he must have been particularly proud of the

single photo that captured interspecific interactions, age polyethism, and myrmecophily all in one go.

Now for my Rodney Dangerfield moment (taxonomists don't get no respect). Something missing from this book, and from any of the previous syntheses of army ant biology, is a section on the species-level taxonomy of army ants. I had hopes when I read Chapter One, which has a lovely mystery story involving the arcane rules of zoological nomenclature and taxonomic priority. But there it ended, with a mention of Max Winston's studies of species boundaries in *Eciton burchellii* (the main protagonist) appearing only late in the book. Admittedly, taxonomy is not in Kronauer's wheelhouse. But a fascinating feature of the army ant story is how parallel taxonomies have arisen for workers and males because they are so rarely found together. Males come to light, sporting a morphological candy box of elaborate genitalia, which have been used as the basis for many species names. Workers gathered from foraging columns form their own morphological clusters, resulting in a separate set of species names. Matching of males and workers has come slowly, yet we now have the molecular tools to readily do so. It is remarkable and somewhat mysterious to me that, with DNA barcoding, we now know more about the species boundaries of myrmecophiles than the army ants themselves!

Let us hope that army ants will continue to course through tropical forests and that naturalists will continue to follow them, learning their ways. Kronauer, for whom critical instrumentation includes both PCR machines and folding stools, is an inspiration. His book is not a culmination but rather a progress report. Like the irresistible urge to follow an army ant column through the dense underbrush of a tropical rainforest, I will continue to follow Kronauer's work as he weaves back and forth between field observations and controlled laboratory experiments. I eagerly await the next installment.

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Q & A

Nathan Morehouse

Nathan Morehouse is an Associate Professor of Biological Sciences at the University of Cincinnati. He graduated in 2000 with his BS in Biology with Distinction in Research from Cornell University, where he studied sexual dimorphism in fly visual systems under the mentorship of Cole Gilbert. He then worked as a professional salmon fisherman in Alaska, a farmhand in British Columbia, and the general manager and sommelier of a French restaurant in New York before returning to science as a doctoral student at Arizona State University. In 2009 he received his PhD for work with Ron Rutowski on interactions between female choice and nutritional ecology in butterflies. From 2009 to 2011 he studied the evolution of seasonal color polyphenisms in butterflies as a European Union Marie Curie International Incoming Fellow, working with Jérôme Casas at the Université de Tours in France. He returned to the USA as an Assistant Professor at the University of Pittsburgh before moving his research group to the University of Cincinnati in 2016. His research group studies the evolution of vision and visual signaling in butterflies and jumping spiders. His work has been recognized through receipt of the Animal Behavior Society's Warder Clyde Allee Award, the International Society for Behavioral Ecology's Frank Pitelka Award, and the grand prize in the Genesee Country Museum's watermelon-seed-spitting contest.

What turned you on to biology in the first place? To be honest, I've never found anything as fascinating as the living world, and I'm easily fascinated. There are family stories of me as a toddler watching insects for hours in our tiny yard in inner-city Rochester, New York. I would bring bumblebees — wriggling and fuzzy between my fingers — to the backdoor to show my mother. She would open the door to find me, often choking back tears from being stung, still carefully holding the fantastical little beasts.

This early interest in living things — especially insects — led to birthdays with field guides as presents, allowance money carefully saved and then spent all at once at the 'local pickup' window of



Ward's Natural Science, and trips behind the scenes of the Rochester Museum and Science Center to identify mystery specimens from my insect collection. My neighbor, known to me and the rest of the neighborhood as Grandma Collins, bought me my first insect net when I was about six. She immediately regretted the decision though because the beautiful gardens she tended so lovingly just happened to be the best places on the whole block to hunt all sorts of elusive insects. And, well, sometimes you swing for a butterfly and catch a begonia instead.

I was a bit older, but not that much older, when I understood that biology could be a career, not just an interest. I was raised entirely without TV, so what I might have learned from nature programs I found instead in the pages of *National Geographic* and the accounts of early biologist explorers, such as Bates and Wallace. I also spent hours reproducing the diatom drawings of Ernst Haeckel with tracing paper and a pencil, and this taught me that being a biologist could be an aesthetic pursuit as much as an intellectual one.

And what drew you to your specific field of research? It's funny how strongly we feel a sense of ownership over our own life path and yet how clear the influences of others become when we step back and examine where we came from. This unique confluence of personal histories is part of what makes human diversity in science so valuable because we each bring with us not just our own selves but some part of the lives of all those who have shaped us.

My interests in animal aesthetics and biological imaging (i.e. animal communication and visual ecology) are easily traced to familial influences. My mother is a talented watercolorist, calligrapher, and musician. Both of my sisters are accomplished artists, my brother a professional musician. And my grandfather worked as an engineer for Eastman Kodak, where he designed optical systems for reconnaissance satellites and pioneered new processes for developing color photographs. Growing up in this environment, it's no surprise that my own interests turned toward understanding how and why beauty evolves in nature.

Is this the source of your interest in collaborations between art and science? Without a doubt! Art and science are both ways of making sense of our world, and they have much to learn from each other. For me, the best art is that which challenges how we think about the world, or reveals something new or unexpected, even in the mundane. The same applies to some of the best science.

As scientists, we're sometimes tempted to view our work as a more effective route to understanding reality, but this perspective hampers the achievement of a richer consilience. For example, I was once told that it was a misdirection of my effort as a junior faculty member to collaborate with an artist friend on a series of interdisciplinary conversations about the role of curiosity in the arts and sciences. Instead, I was counseled to write more grants. But the transformative experiences that emerged from these conversations (I ignored the advice!) — conversations that involved the voices of philosophers, musicians, historians, and neuroscientists — led directly to ideas in my next two successful grants.

What might such consilience look like in modern academia? I think that this can take many forms, but it begins with fully respecting the value of other ways of knowing. For example, one of my current 'passion projects' is the development of a new interdisciplinary research institute here at the University of Cincinnati called the Institute for Research in Sensing (IRiS), launching in early 2021. Cincinnati is home to campus-wide strengths in sensory biology, sensor

technology development, and perceptual psychology. The project of IRiS is to unify these STEM perspectives with equivalent strengths in the humanities, social sciences, and fine and performing arts. From the beginning, we've sought to value non-STEM perspectives with a leadership team that includes an ethicist, a scholar of Afrofuturist literature, and a philosopher alongside a biologist, chemist, psychologist, and engineer. This disciplinary breadth opens up new possibilities for inquiry. What ethical issues accompany new wearable sensor technologies, such as Fitbits and Apple Watches? What role does speculative fiction play in our imagining of new technologies? Can fashion teach us something about human health? Non-STEM perspectives not only help us to explore what is possible, they also challenge us to consider what is good.

What do you see as the biggest challenges facing your area of science? It's an exciting time to be a sensory biologist because now more than ever we have the tools to understand how organisms sense the world. Much of that work has been dedicated to characterizing how particular species see, smell, hear or feel. But a grand challenge moving forward is to connect these macroevolutionary patterns of sensory diversity to microevolutionary processes. This requires a shift in our thinking from ignoring individual variation in sensory performance to exploring the causes and consequences of such variation. How does an opsin duplication spread through a population? How do the neural networks enabling mate choice evolve within and across species? Answers to these questions will require integration of fields beyond sensory ecology proper, including population genetics, evolutionary ecology, developmental biology, cognitive neuroscience, and molecular biology.

More broadly though, I believe that science also faces a crisis of human diversity. For too long, scientific institutions around the world have failed to address racial and gender imbalances in the scientific enterprise, often by appealing to a meritocratic ideal that ignores the existence of injustices. And these injustices are endemic not only to society writ large but also our institutions. Deceptively simple answers such as "we just need to get [insert

minoritized population X] interested in science” not only misestimate the problem, they are deeply insulting. Surely the overrepresentation of white males in positions of power in science is not simply because white males are more interested in science! Addressing these inequities is not just a professional challenge, it is also a deeply personal one. Those of us in the majority, including myself, must engage in radical self-examination. How have we contributed, wittingly or unwittingly, to the situation at hand? And how should we help to bend the “arc of the moral universe” toward justice?

What form has this latter challenge taken for you personally? I’m a white, heterosexual man, so a major part of this for me has been examining the privileges that I have enjoyed my entire life. It’s humbling to realize that one’s successes in life have been underwritten in part by advantages of identity rather than merit. But I have come to realize that my life has also provided me with opportunities to empathize with and address the challenges that others face. I grew up in a proud Black neighborhood, the 19th Ward of Rochester, New York. I can remember the age, right around 12 or 13, when my friends began fitting the generic suspect descriptions of neighborhood police: “Young Black male, medium height, ball cap.” That applied to half my block in the summer! At the time I was relieved not to be a target but also offended by the injustice it presented to my close friends. Recently, my friends and I have been revisiting these memories, a process both difficult and healing.

But there are also other lessons from my childhood that I have been drawing on of late. My parents dedicated their lives to serving their community in ways that still inspire me today. For example, nearly all the patients in my father’s small medical practice were Medicare–Medicaid recipients, and I can remember times when my parents struggled to put food on the table because there wasn’t enough money coming in from billable reimbursements for my father to pay himself after he paid his staff. He could just as easily have moved his practice to the affluent suburbs, where his income would have quadrupled. But instead he remained dedicated to the conviction that everyone deserves access to quality medical care. Watching him struggle

to bring that vision into the world in the face of financial and political headwinds taught me a crucial lesson about dedication to the greater good.

So, for me, this has been a personal journey to reconcile what has been, what is, and what should be. It has involved reading, listening, making mistakes, being vulnerable, and also reckoning with what I can and should do from my position of privilege.

In your opinion, what are things that scientists, particularly those in the majority, should be doing to address the problem? There are quite a few things to do, but all of them start with ‘doing the homework’. There is a wealth of excellent writing about issues of social and racial justice. We should be reading this literature first, rather than relying on the minoritized colleagues in our departments to do the work of teaching us about their struggles. This homework extends to being mindful of history and place. Are we inviting minoritized students and colleagues into environments where they will feel safe and valued? Are these places where it is easy for them to imagine thriving as their true selves? This involves a re-encountering of the places we work and live. What is the history of race relations or LGBTQIA relations in your city? On your university campus? Do you live in a ‘sundown town’? What is the graduation rate of persons of color in your local public schools? Your university? True history cannot be revised, but being aware of it helps to inform the best steps toward righting past wrongs.

I’ve also been working with colleagues to examine the ways in which our gatekeeping has resulted in the exclusion of diversity rather than the promotion of excellence, from our graduate recruitment and admissions policies to our criteria for promotion and tenure. The newfound openness to meaningful changes on this front has been encouraging. More broadly though, re-examining gatekeeping is about opening up space for others whose path to excellence may be different from your own. What worked for you may not be a good template for what would be best for others. How do we share opportunity? And this charge is just as much a personal one as it is a professional one. It doesn’t matter how committed one is to equity in the workplace if one treats a young Black stranger with suspicion in a public park.

If you had not made it as a scientist, what would you have become? I’ve had many ‘plan B’s’ over the years, some more reasonable than others. For example, I told my parents at 13 that I was going to drop out of school and move to New York City to become a professional jazz musician (after taking Miles Davis’s autobiography too much to heart). I’ve also tried my hand at, and seriously considered becoming, a professional photographer, a farmer, and a sommelier. The most recent of these daydreams has been to go into the spice trade. I love to cook, a pastime that is enlivened by my particular form of synesthesia, in which flavors and odors are associated with vivid colors. So cooking is something of a painterly experience for me, and spice shops are lusciously psychedelic. But beyond this hedonistic aspect, spices are also fascinating from biological, historical, and anthropological angles. So much human inventiveness has gone into the particular spice palettes of cuisines around the world. It would be a delight to share this richness with others through community-oriented culinary education and socially responsible sourcing of spices.

Do you have a favorite quote you would like to share? I’ll be greedy and share two, if that’s okay. The first is from French surrealist poet Paul Éluard, who wrote: “Il y a un autre monde mais il est dans celui-ci”, which loosely translates to “there is another world, but it is in this one”. To me, this quote speaks to the magic that still remains to be discovered, even right in our own backyards. One need look no further than here and now to find “another world” brimming with surprises. The second is from James Baldwin, American novelist and activist, who wrote: “One can give nothing whatever without giving oneself — that is to say, risking oneself. If one cannot risk oneself, then one is simply incapable of giving.” In this age where immediate gratification and individual benefit have been elevated to the status of virtues, we need Baldwin’s reminder more than ever that true giving is a radical act that demands self-sacrifice.

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