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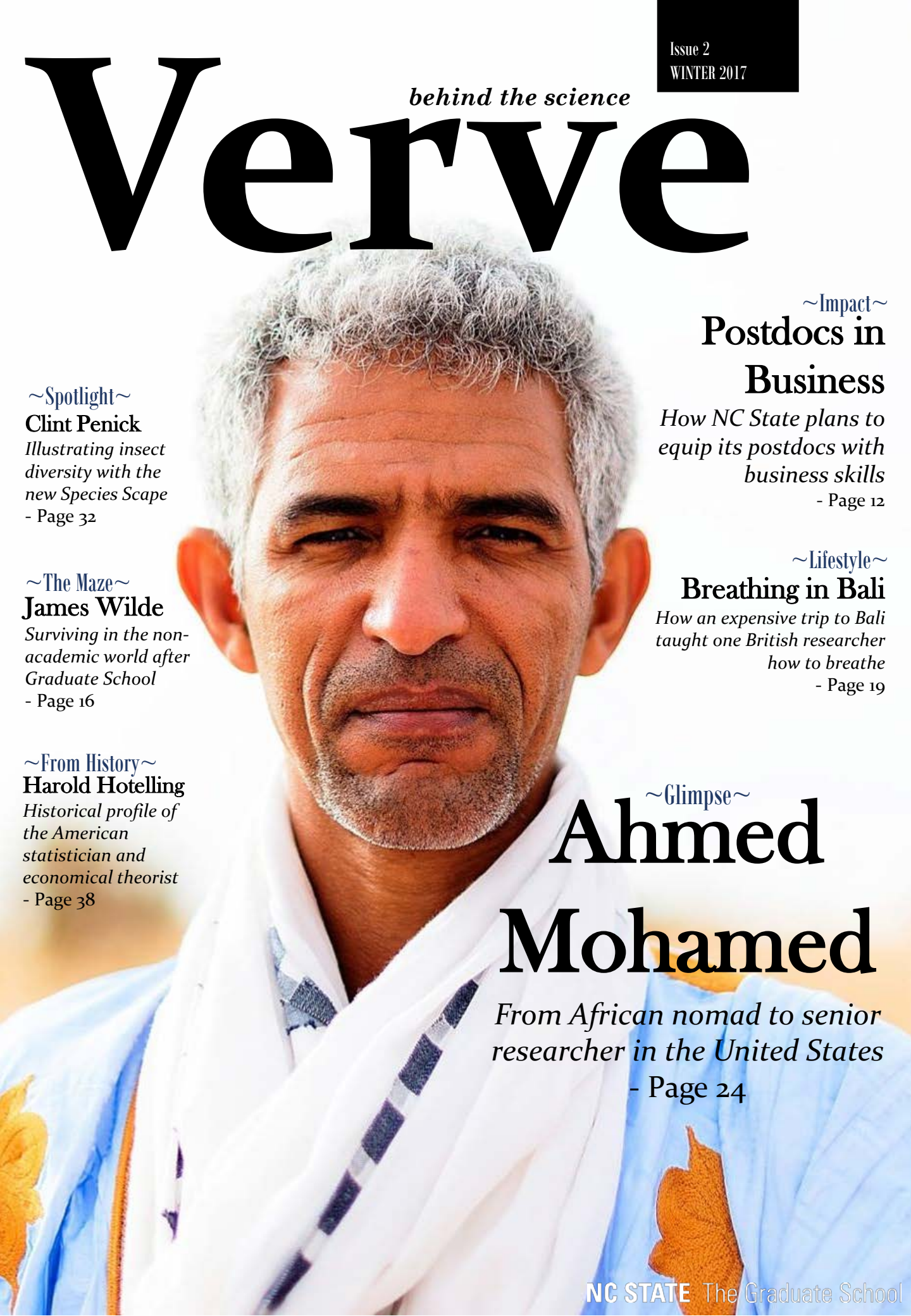
WINTER 2017

Verve

behind the science



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"It is not the strongest species that survive, nor the most intelligent, but the most responsive to change."

– Unknown

Photography credit: Ahmed Mohamed

Verve

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Verve

WINTER 2017
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WHAT'S INSIDE






Dear Postdocs,

It never ceases to astound me just how far we humans, mere bundles of atoms programmed by DNA and governed by electrical impulses, can push the boundaries of science.

In 2016 alone, we identified the biggest and most distant galaxy cluster yet (memorably named IDCS 1426), which sits roughly 10 billion light years away; detected gravitational waves, finally proving Einstein's theory of relativity; discovered the fossilized remains of a pregnant *Tyrannosaurus rex*; implanted a chip in a quadriplegic man's brain so he could play the guitar; parked the *Juno* spacecraft in Jupiter's orbit; discovered that a common insecticide has devastating effects on bee sperm; sequenced DNA in outer space; and found that the ancestors of all non-Africans today come from a single population in Africa, who emerged from Africa between 50,000 to 80,000 years ago.

Science has an undoubtedly profound impact on our lives through an extraordinarily diverse variety of fields and sectors. Academia is just one of these sectors, albeit a significant one, within which scientists create new knowledge.

It is important to emphasize that academia is not the only path successful scientists can follow, and that the range of opportunities that exist is broad and varied. The increasing number of talented science PhDs is far outpacing the available traditional tenure-track faculty options, but outside the academic sector lie countless possibilities for scientists to contribute significantly to our understanding of the universe.

Within this issue we not only confer and enjoy the diversity of academic scientists and their work, but also discuss the need to bridge academia with the non-academic world outside.

If we can see fluidity between these two domains, suddenly the shortage of faculty positions doesn't seem so daunting. Instead, we can see the postdoctoral position for what it actually is: a training ground for the minds who will drive the next year of scientific advancement in more ways than one.

- Greer Hawkins
Editor of Verve

Photography credit: TheTrident (Flickr)

Preparation for becoming a teacher is essential for those looking to achieve a teaching faculty position, says THOMAS LENTZ, and it goes beyond the classroom experience.

Learning To Teach

If you're a postdoc like me and want to secure a teaching faculty position, eventually you're going to find yourself seated in front of a research committee and answering the question "how will you engage undergraduates in your research?"

Even with teaching experience, the answer to this question is not immediately obvious unless you're well prepared. Assisting in classes or labs, supervising students and lecturing are all worthwhile exercises, but the transition from postdoctoral trainee to faculty leader requires a significantly larger leap.

You wouldn't be alone if you weren't sure which career path you wanted to follow, or even whether you wanted to stay in academia, but I've been determined to follow the teaching faculty route ever since I started my teaching postdoc position in NC State's Biotechnology program.

All postdocs are acutely aware of how challenging it is to obtain a faculty position. My approach has been to make myself competitive by building a research program specifically suitable for integrating undergraduate students at institutions such as UNC Asheville, High Point University and Warren Wilson College.

In these institutions, research is secondary to teaching, so approaching my research from a teaching angle rather than a grant and publication-dominant focus has been essential. If you are considering a similar path, perhaps my experiences will help you

see how your own research can be adapted to incorporate undergraduate education.

A predominant challenge I faced when developing my teaching-oriented research program was achieving a balance between relevance and resilience; the program had to generate publishable data, but the work had to be suitable for the technical skills of an undergraduate student.

The project at the center of my research program was the ecology and molecular biology of ranaviruses, a group of large double-stranded DNA viruses that infect cold-blooded animals such as reptiles, amphibians and fish. The topic itself is extremely interesting; ranaviruses can be lethal in some species and were responsible for more than half of the extinction events in amphibians that occurred between 1996 and 2001 in the United States.

Although fascinating, as a project for undergraduates ranaviruses presented various problems, the most obvious of which concerned safety and technical ability. Creating a safe and simple project was key to ensuring that the balance between relevance and resilience was maintained.

Accordingly, my first challenge was navigating health and safety. During my search for faculty jobs I realized that not all undergraduate establishments provide the same facilities to ensure adequate safety when working with different biological agents. However, my choice of ranaviruses for the project made safety an easy hurdle to overcome: ranaviruses do not pose much of a threat to humans since they are incapable of infecting humans.

Although more harmful viruses might be of greater appeal to research-intensive projects, the minimal threat posed by ranaviruses made their hazard level suitably low for undergraduate work and therefore a more productive choice for a teaching program. Compensating the research focus for more profitable teaching gives students more freedom and a better learning experience, while simultaneously providing valuable lessons in health and safety.

The limited time and technical proficiency of undergraduate students also proved challenging for the program's design. As well as possessing little or no research experience, students work through a busy schedule of classes, coursework and exams. Designing a program that could harmonize low work intensity with meaningful scientific contributions was essential. Routine daily work was minimized by using simple systems – a low maintenance cell line, for instance – and all experiment plans were made flexible to suit different schedules and capabilities.

Equipment is also a limitation of undergraduate work. This varies between institutions, but research questions must be designed around the tools available. To encompass a broad range of facilities I ensured my research aims were suitable for a spectrum of equipment, from the very basic to more specialized and expensive.

Photography credit: Thomas Lentz

Photography credits (this page): Thomas Lentz

By providing myself with a broad range of aims I was able to accommodate a variety of different campuses and facilities without compromising the research output. An opportunity to buy more specialist equipment may arise if you secure a faculty position with a startup package, so being able to demonstrate how this technology could benefit the campus would strengthen your project and employment – but be prepared to work without this technology first.

Finally, I considered how to teach in a classroom environment. In a faculty teaching position you will be expected to teach several classes relating to your field of expertise, and most likely be required to develop an entire curriculum. To begin with, integrating the research subject into the classroom material is useful for the students but also demonstrates how your program fits into the primary mission of your target institution. Utilizing your research as a teaching tool allows you to use your expertise to engage your students and help them contribute to publishable data.

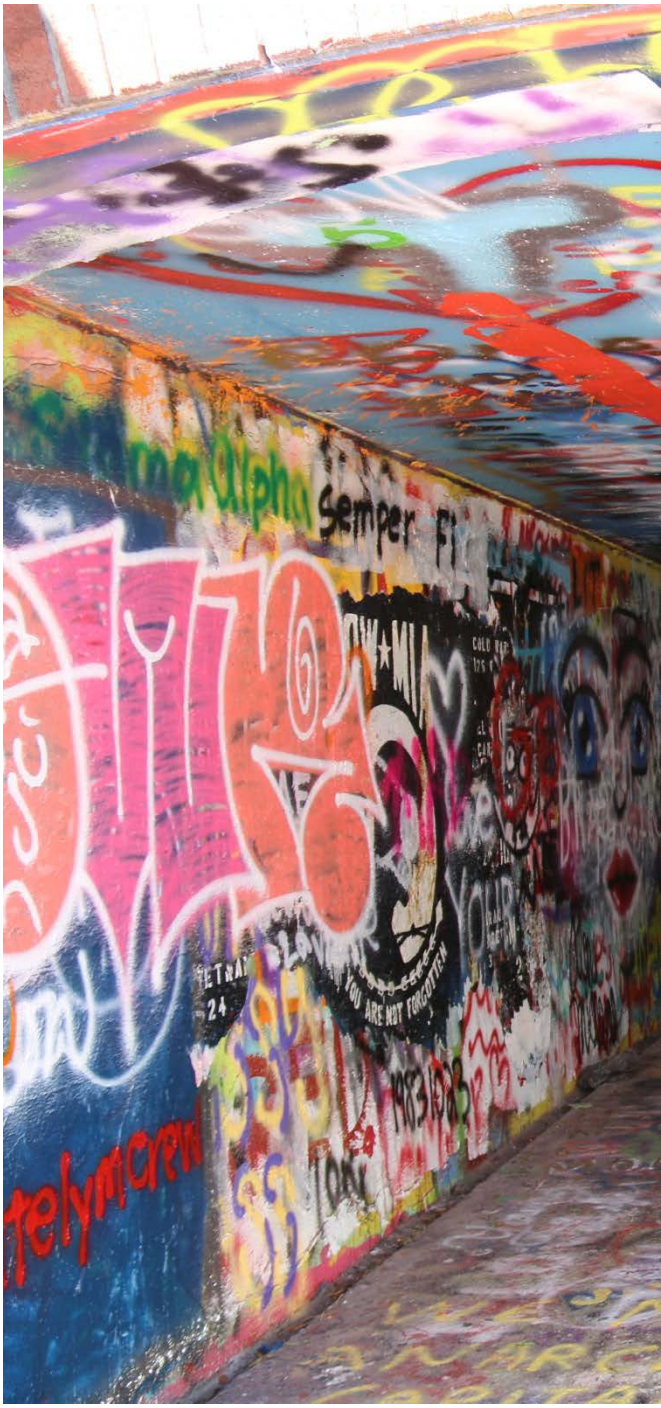
For the ranavirus project, as well as taking students on field trips to collect samples I also planned my class teaching to introduce the theory behind the protocols and techniques used in the lab. Not only does this teach the fundamental basics of various topics, ranging from genetics to immunology, these lessons also allow the students to make connections between their class work and their practical research, cementing the entire project into a thorough, interactive learning experience. By steadily encompassing more demanding techniques and principles, the program can be expanded so students have the chance to progress and apply their new, learned knowledge.

Demonstrating that you have the ideas and capability to build a research program around an educational curriculum specific for undergraduates will make you a strong competitor for teaching faculty roles. Undergraduate students are extremely rewarding to work with and capable of performing excellent research with the right program and supervision. Productive research does not always demand high priced equipment and personnel, and it is entirely possible to merge education with a prolific research environment. With careful planning and consideration, a teaching-oriented research program can provide an ideal platform for nurturing the next generation of researchers. ■

- Thomas Lentz

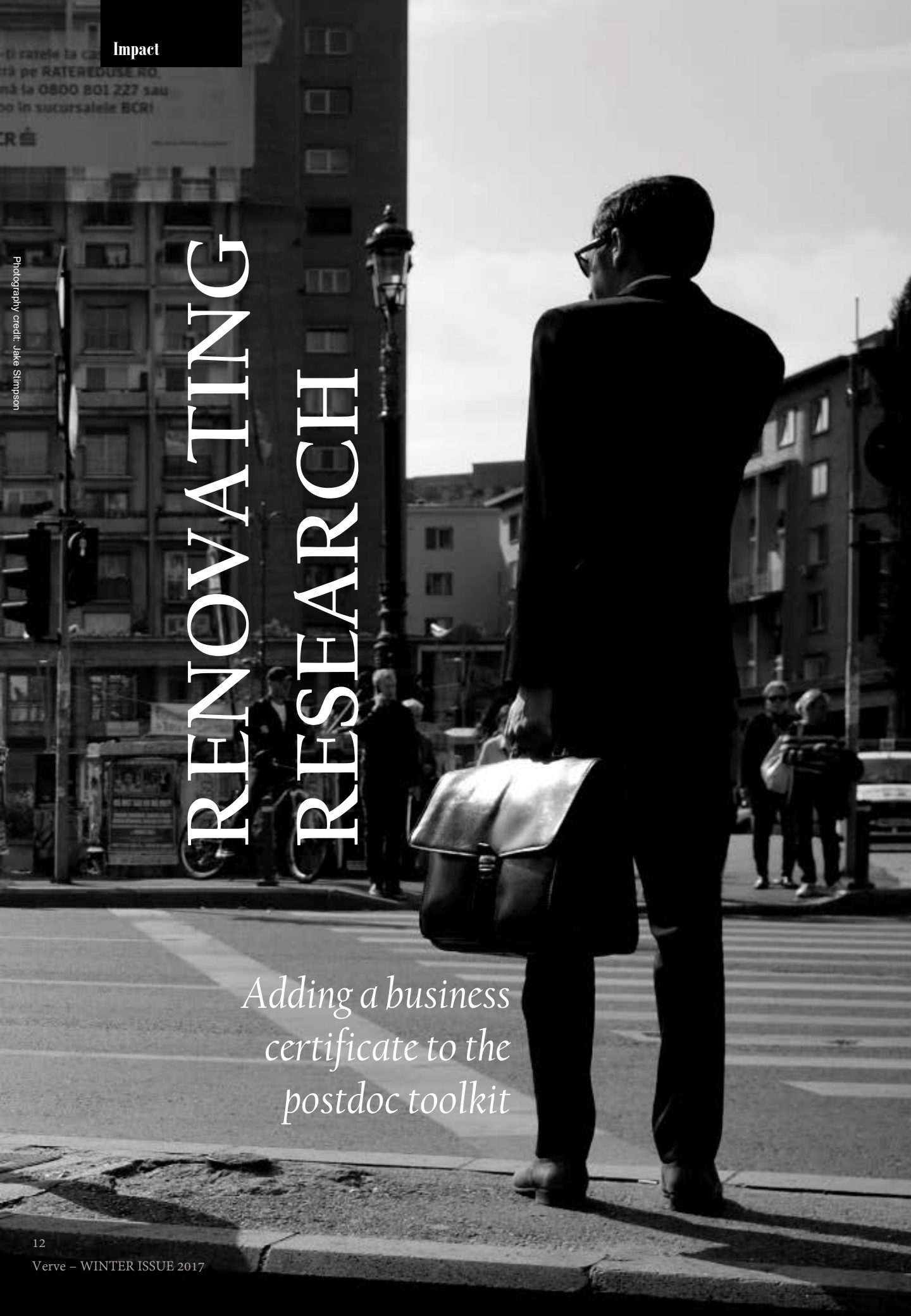
NC STATE

The Tunnel of Free Expression



Photography credit: XINGLI MA

Since its innovative purpose was established over 50 years ago, the Free Expression Tunnel has achieved the auspicious objective of combatting widespread graffiti on campus while simultaneously celebrating this internationally notorious subculture of art. Graffiti in the tunnel ranges from the profane to the profound, from advertisements and political commentary to abstract art and profanity. The Tunnel, located on Central Campus, connects the two halves of campus split by the railroad track. The Free Expression Tunnel undergoes frequent transformations as art is layered upon art, providing an inexhaustible canvas for anyone wishing to let off a bit of creative steam.



Photography credit: Jake Stimpson

RENOVATING RESEARCH

Adding a business certificate to the postdoc toolkit

Despite being at the forefront of pioneering research, academia is, at times, conspicuously old-fashioned, and one division that is ripe for an update is postdoctoral research.

Once a profitable step towards a faculty appointment, the postdoctoral position is now challenged by poor employment prospects. In the US, while more than 60% of PhD graduates become postdocs, fewer than 20% of these researchers continue into tenure-track positions. Problems such as funding competition and job shortages play their part in this crisis, but an outdated mentality is also to blame. Aiming for permanent tenured positions is no longer a realistic target for many researchers, yet this approach is considered the norm and pursued by the majority.

To counteract this complacency, NC State is among a handful of universities that intend to renovate the postdoctoral experience. Their proposal? To equip junior researchers with practical interdisciplinary skills relevant to a wide range of disciplines, beginning with a qualification in business.

Among many potentially useful interdisciplinary skills, business is arguably one of the more transferable and broadly applicable. Like any other field, business appears uninspiringly vague at first but becomes more specialized once the basics are learned.

As an umbrella subject, business encompasses various disciplines including accounting, finance, sociology, law, strategic management, data analytics, economics and business policy, to name a few. Teamwork, leadership and networking are also useful lessons, but the discipline itself also goes deeper, teaching the underlying operations of organizations and the effects of external influences such as economic fluctuations.

To allow postdocs at NC State to study business alongside their research training a certificate program has been proposed, spearheaded by Professor David Baumer and Dr Laura Demarse of NC State and their collaborator Dr Wade Chumney of California State University. If implemented, the program would become an optional resource for all NC State postdocs.

Importantly, the program would be recognized as a core feature of postdoc training by both postdocs and faculty advisors, rather than a dispensable extracurricular activity. To fulfill this, program activities would be legitimately incorporated into normal working hours if the postdoc chose to enlist. A modernized academic mentality requires not only that interdisciplinary skills be taught, but also the acknowledgement that such skills are crucial for postdoc training. In the multifaceted non-academic world careers are fluid, sectors are interchangeable and a rigid career ladder is no longer beneficial; postdocs who now face a greater chance of continuing their careers outside academia must be allowed to prepare for this.

However, to compete with the hours demanded by the research, this supplementary program must be worth its weight in time. If the end goal is to secure a desirable non-academic job in a related area, the business program must provide postdocs with more than just another certificate with which to decorate their CV.

Ideally, the business skills learned should complement the research and analytical expertise that postdocs already possess. A component of the proposed program that could provide this lesson is a business-based scenario, during which postdocs would work with experienced executives and a target business to tackle "real-world" projects. Presentations delivered to business executives would also form a central part of this project to ensure each postdoc understood how science and research fit within the

"Postdocs who now face a greater chance of continuing their careers outside academia must be allowed to prepare for this."

momentum of a corporation.

Expectedly, however, the program requires an investment of not only time, but money too; the fees of the proposed program may act as a deterrent to skeptical researchers. For those able and willing to pay the tuition costs, the program must also contend with equivalent master's degree courses and temporary internships offered by potential employers.

Likely strengths of the program are its integration into postdoc training and that postdocs rather than graduate students are the target scholars. Importantly, NC State postdocs work in social sciences and humanities, not just science and engineering, and the business program should consider this. If designed well, the program would allow postdocs to gain relevant business skills while still pursuing research, rather than the alternative option of pausing the research to complete a master's degree.

Provisionally, two main subjects of the program would be strategic management and data analytics. Given that postdocs analyze data daily, the modification of data analytics to suit specific business-related jobs and scientific fields would lend the program a competitive edge. The remainder of the program could be tailored to the career goals of each postdoc by allowing them to choose from a list of modules such as finance, ethics, marketing and law, among others.

If the personalized selection of modules was preceded by an in-depth review of potential non-academic job opportunities, this program could be particularly profitable for postdocs. Options such as launching a startup company have more obvious associations with business, but a great variety of other non-academic jobs such as technical support scientist, consultant, science liason, recruiter, technical writer, project coordinator and product specialist have less palpable ties.

"A pivotal element of the proposed program is that the target scholars are postdocs rather than graduate students."

Startup companies are an obvious link to business, but what about other jobs? Postdocs must know why they need a business certificate before they start the training.

Additionally, positions vary between companies and sectors: government divisions, such as the Department of Health, differ substantially from private companies. Likewise, the skillsets sought by employers from non-profit organizations and hospitals vary to those required by industrial companies and contract research organizations. Understanding the spectrum of the job market will allow postdocs to make informed decisions about the business program and their training choices.

Convincing postdocs to sign up for yet more training is no straightforward task, and for good reason. Progress in academia requires data, publications and grant proposals, all of which devour precious time. The low probability of reaching a tenure-track position raises the stakes of taking time out of research even further. Leaving academia is a necessary rather than favorable choice for many, so the benefits of the business certificate program must be realistic. If the program can become a training resource specifically useful for postdocs, this could be a positive step towards renovating the academic mentality and improving postdoctoral research. ▮

- Greer Hawkins

NC STATE

STRESSED?
CONFUSED?
NEED TO TALK?

Call the
COUNSELLING CENTER

The NC State Counseling Center is a resource that is available not only to undergraduate students, but also to faculty and staff, including postdocs. Individual counseling sessions focused on personal or career concerns can provide some much needed impartial perspective that is challenging to get from family and friends. Personal counseling can focus on issues ranging from stress and anxiety, to relationship issues and substance abuse. The Counseling Center also offers group counseling sessions to provide opportunities to seek support and advice from others with similar experiences. Sessions are kept strictly confidential, and most services are free to postdocs who have health insurance through NC State.

The Counseling Center can be found on the second floor of the Student Health Center, located at the corner of Dan Allen Drive and Cates Avenue. For more information about services and resources, visit the Counseling Center website at https://counseling.dasa.ncsu.edu

Thanks to Angel Bowers (abjohns2@ncsu.edu) for this information

Photography credit: Hernán Piñera

James Wilde

Eliminating postdoc tunnel vision

In 2004, James Wilde left NC State to launch a new career in the corporate arena. Twelve years later, he returned to NC State as Head of Agribusiness for the New Zealand government's Trade and Enterprise Agency (NZTE) to explain precisely why business skills are a good investment for postdocs.

"Postdocs have a huge advantage in the private sector because science is fundamental to all the biggest corporations," says Wilde. However, he adds, "if postdocs do not branch out from their intense area of expertise, they will ultimately do themselves a disservice."

Shaped by their academic training, postdocs finely tune their focus to such precision that they become specialists in their field. However, as significant a part as this process plays in research and development worldwide, this constricted, tunneled concentration can be detrimental to their own careers.

Awareness of the liability of being *too* focused has spread alongside the swelling of the postdoc population. As *post*-postdoc academic positions remain dismayingly scarce, many postdocs remain stuck in a peculiar career limbo, unable to escape by simply churning out more publications or accepting more teaching roles. But even for those researchers who have always anticipated an exit from academia, the restricted targets of publications and grant proposals prevent the next career step from being as well-informed and profitable as it could be. Taking time to prepare and acquire transferrable skills is crucial.

"Everything is interdisciplinary," Wilde explains. "The global world operates across intersecting sectors." Unlike academia, with its narrow routes towards the most desirable jobs of permanent faculty and professorship positions, non-academic career paths are far less methodized. Instead, professions shift and oscillate across different disciplines, weaving up and around multifaceted career ladders with innumerable branches and links. For any postdoc considering a leap into the outside world, being ready for a fluid and changeable realm of employment is nothing less than vital.

"I discovered very quickly that the private sector is completely different to [academic] research," says Wilde. After realizing he had an idea that might appeal to the corporate world, Wilde made the intrepid but calculated decision to embark on an entrepreneurial pursuit. Here, his business skills – strikingly distinct from his microbiology and marine biology training – became invaluable.

"An education in business became essential because it gave me a fundamental understanding of the main principles of business, and the dynamics of how a business will function," describes Wilde. From a comprehension of profits and debts, to how a product becomes valuable to a company, understanding business allowed Wilde to utilize his existing expertise and survive in a non-academic environment.

"This is applicable to absolutely everyone," says Wilde. "For instance, if an artist wants to sell their art, they need to be able to balance their checkbook. They can't just rely on their art alone."

Importantly, Wilde also recognized that setting up a business didn't mean he was aiming to

"Postdocs have a huge advantage in the private sector because science is fundamental to all the biggest corporations."

make it "big" on his own. As he developed his own business his aim was not to create an entirely new corporate entity, but instead was to work alongside those who were already established and successful.

"It was about vertical integration," continues Wilde. "The big companies are already out there. I knew I needed to portray my product as something that would complement those existing companies." By understanding his field in the global market, Wilde structured his corporate plan to ensure his product could be seen as "useful" to the businesses already working in the same arena.

"Working in academia is valuable because it allows you to build yourself as a brand through your own publications," Wilde says, contemplating postdoctoral researchers who may want to enter the business world. Before leaving academia, postdocs can make the most of their research setting by using it as a platform for preparation. Attending conferences and presenting research provides ideal opportunities for networking and being seen as a dependable and promising researcher, who could translate research into beneficial products. What's more, he continues, "there are always corporate sponsors at conferences." Conferences are ideal for recruiting financial backing and support, but also for interacting with potential sponsors. This provides researchers with an opportunity to learn more about what prospective clients might want from a new business.

"You always have to have a long-term view," says Wilde, and explains that there are other tools that postdocs should arm themselves with, many of which are particularly simple. "If you haven't got your own business cards, you need to get some." His point is elementary but paramount to building contacts: people will never know your value until they need you, so you're off to a head start if they walk off with your business card in their pocket.

"One of my strengths is recognizing when someone could be valuable or helpful to me later."

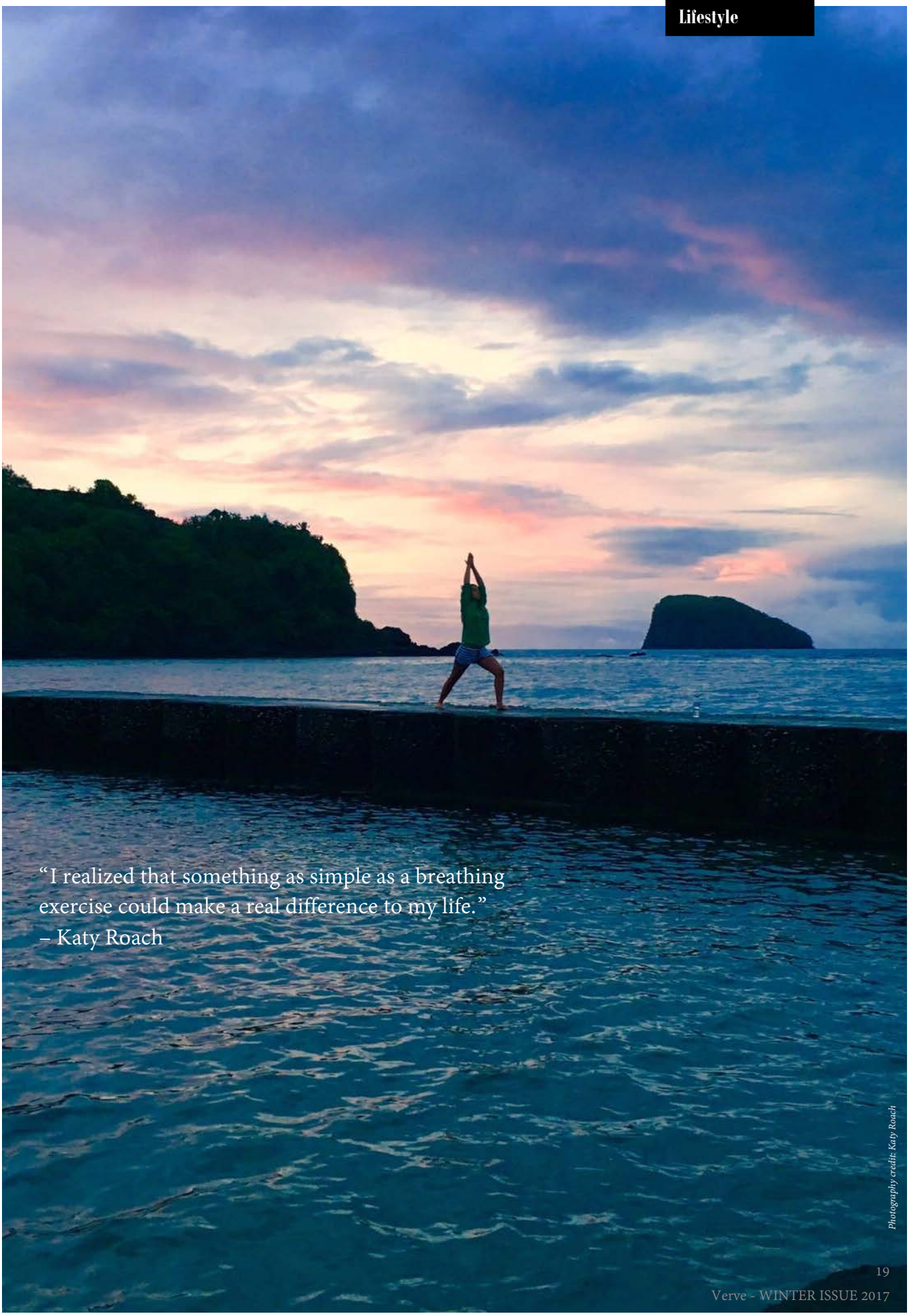
And after business cards? "Get yourself a mentor," Wilde says. Leaving academia should not be a case of reinventing the wheel. No matter what sector or field, existing expertise is ubiquitous and a practical tool to exploit. "I think one of my strengths is recognizing when someone could be valuable or helpful to me later," explains Wilde.

Wilde makes no implication that the transition from academia to the business-based science sector is easy. He reflects that his own leap into the private sector was a risk, but one he has never regretted.

"I just loved it. It was me driving for it on my own all the way. There was a certain freedom to what I was doing," Wilde recalls.

Amongst the lessons and pieces of advice he received along the way, he mentions one that has stuck with him throughout, and one he feels could be of particular benefit to all postdocs: "Don't ever confuse movement for progress," Wilde counsels. "Just doing something doesn't mean you're moving forward. Circumstances will always change, and you must consider what is needed tomorrow." ▮

- Greer Hawkins



"I realized that something as simple as a breathing exercise could make a real difference to my life."
– Katy Roach

Photography credit: Katy Roach

Breathing in Bali

KATY ROACH takes us to Bali and describes her own expensive lesson in mindfulness

As a respiratory scientist who specializes in progressive lung disease, learning how to breathe has not appeared on my to-do list for a long time. In fact, until recently I was pretty sure I'd successfully crossed breathing off my list as a mastered skill many years ago, a few moments after I was born. And yet, earlier this year, sitting cross-legged on a yoga matt about 8,000 miles away from my lab on the balmy shores of Bali, I found myself being told by some "*ammmmmmm*"-ing yoga teacher that for the past 30 years I've been doing it all wrong. Needless to say, I suppressed a snigger.

Opening one eye and sneaking a glance at the instructor, who was seated at the front of the class against an exotic backdrop of palm trees and breathed in silence with her eyes closed, I was already halfway to deciding that this soothing waffle about breathing, flow and energy had been nothing more than a cunning career move and a surefire way into unsuspecting wallets.

My silent grumbling was made only worse by my misunderstanding that yoga is all about intense stretching and strengthening. Until that moment I'd been preparing myself for a grueling but rewarding session of planks, downward-dogs and sun salutations, so a lesson in alternate nostril breathing (*Nadi Shadhan Pranayama*, for the yoga-literate among you) seemed nothing more than a frustrating disappointment.

But after several minutes of disgruntled thoughts, perhaps realizing that my wallet was evidently one of the unsuspecting ones and therefore it was my own money being wasted, I eventually gave in and started to listen. I sat still, closed my eyes and focused on following the softly spoken instructions. No sooner than 2 to 3 minutes later, my opinion of the breathing lesson had been overturned. I really did need to

learn how to breathe. Better yet, I realized that something as simple as a breathing exercise could make a real difference to my life.

My day job as a postdoctoral researcher, by definition, means my brain never switches off. Whether considering potential theories, contemplating yesterday's data or reshuffling tomorrow's experiments, my mind is never quiet and the days fly by without me even taking a moment to notice.

Before I dabbled in yoga I relied on an intense workout for some relief. There are, of course, many benefits of exercise: endurance sports such as cycling and long-distance running increase cardiovascular and respiratory capacities, and more specialized training such as weight-lifting improves muscle strength and bone density.

But perhaps most importantly, and admittedly subconsciously, exercising gave me valuable time to switch off and reset. At the end of each session I'd be exhausted and dripping with sweat, but revitalized nonetheless.

Being present, existing in the *now*, is not something I have ever given much thought to or practiced. The word "mindfulness" is thrown about in the occasional well being-oriented conversation I've half-listened to, but before yoga I had never deemed it to be particularly important in my vocabulary.


Photography credit: Katy Roach

"My mind is never quiet and the days fly by without me even taking a moment to notice."

The Oxford Dictionary defines mindfulness as "*a mental state achieved by focusing one's awareness on the present moment, while calmly acknowledging and accepting one's feelings, thoughts and bodily sensations*". Several pages after this the definition of stress can be found: "*A state of mental or emotional strain or tension resulting from adverse or demanding circumstances*". Having survived five years of postdoctoral research, I've since decided that those very words, "*postdoctoral research*", would not look out of place as an alternative definition of stress.

The fast-paced nature of research often pushes me into a habit of either living a few days ahead into the future to plan what I need to do, or revisiting the weeks gone by to reassess what has already happened. This is only intensified by the overpowering pressure to generate data, to publish, to write retaliations to that harsh reviewer, or to wonder whether my hard work will keep me employed in the same lab next year. The unfortunate reality of these conditions mean stress is a heavy weight that I carry on my shoulders each day. As burdensome and draining as this is, I've always assumed stress was an unavoidable accompaniment of research.

Chronic damage inflicted by stress occurs when stress is both uninterrupted and persistent. As I sat on my yoga matt, observing my breaths and being blissfully aware of the tropical sounds around me, I realized this yoga lesson was not about learning to breathe, but for me was about letting the knots of stress unwind and bringing my focus back to the present.

Focusing on each breath was surprisingly challenging - my thoughts were relentless. But with each breath, focusing on where the air flows and how my body feels, I found myself not keeping the thoughts at bay, but instead allowing my thinking rate to slow and eventually come to an almost complete stop. The release this provided was immense and immediate.

Returning to the now, the very second you are existing in, and allowing all anxieties, stresses and unnecessary thoughts to dissipate is more cleansing than any sweaty workout or even a long deep sleep, and certainly more effective than working longer hours to squeeze out more data. By focusing on each breath you eventually reach a moment in which you are wholly consumed by being *you*, with absolutely nothing to contemplate, worry about or even feel, other than exactly where you are right now.

Photography credit: Katy Roach

At the end of the session, as I rolled up my yoga matt, my rate of thinking began to steadily increase to its usual speed. The difference was that as the thoughts flowed in I felt as though they were entering an expansive space, rather than piling up on top of an already overflowing mound.

Several months on from this experience in Bali and I am a significantly less stressed individual and I have redesigned my approach to exercise. Yoga has taught me that giving my brain a break makes my work and life far more enjoyable and sustainable than ploughing on incessantly, dragging a weight of stress along behind me.

It took an expensive holiday in Bali for me to learn a lesson that has undoubtedly changed my life for the better, but hopefully by reading this you'll save a few pennies and realize that it really does pay to take time out, and to just sit still and breathe. ▮

- Katy Roach

Katy Roach is a postdoctoral research scholar at the University of Leicester, UK. She received her undergraduate degree in Forensic Science from the University of Lincoln, and after travelling around Asia, Australia, New Zealand, Fiji, and Mexico with her then-fiancé, now husband, Roach undertook a PhD in Respiratory Medicine at the University of Leicester.

Roach's current research is focused on the role of a particular ion channel, $K_{Ca}3.1$, in the progressive and lethal lung disease, idiopathic pulmonary fibrosis. Her published work can be found in the Journal of Immunology and the journals Respiratory Research and Fibrogenesis and Tissue Repair.

NC STATE

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Ahmed Mohamed

From desert nomad to senior researcher

Photography credit: Ahmed Mohamed

On a sunny afternoon in Raleigh, North Carolina, Ahmed Mohamed sits in a Port City Java café more than 4,000 miles away from his childhood home in Mauritania, Africa. As the interview begins and he describes his previous life as a desert nomad to me, it quickly becomes apparent that beneath his mild manner and placidity thrives a remarkably tenacious individual.

This tenacity, while a quality paramount for a career in research, played a prominent role in Mohamed's childhood years before he even realized the existence of science as a practice.

"I grew up in Mauritania where most people live as nomads." Mohamed says. Mauritania sits within the Arab Maghreb in western Africa and is mostly blanketed by desert. "We lived in tents and would pick up our tents to move to new pastures. We always travelled towards the rain."

The setting sounds thrillingly stark, faraway and beautifully uncomplicated. But for someone with an inquiring mind, the endless drifting of a nomadic lifestyle would only take him so far.

"At home I was always going in the opposite direction to everyone else," Mohamed says. He recalls a specific example, his decision to avoid playing sports with those he travelled with, simply because playing sports was something that everyone did. "But I'm not rebellious. There just has to be a convincing argument for why I should do something."

As soon as he was old enough, Mohamed, like many nomadic travelers, started school. But after one particularly severe drought his family were forced to trek further and his daily journey to school stretched to more than 100 miles. To continue his education he left his nomadic life behind to live with relatives in a comparatively built-up, urban area.

"These urban places were very different to the western idea of urban," Mohamed notes. "Where I lived with my relatives, it was still very rural. The only difference was that people stayed in one place rather than travel around." The decision to change his lifestyle would ultimately lead to him leaving Mauritania altogether.

"I graduated in 1992," Mohamed says. "But at that time there were no universities. There was no science." Unable to provide further education, the Mauritanian government ranked its students according to their high school grade point average (GPA) and sent them to foreign universities, a process that tested Mohamed's non-conformist nature.

Rather than choose for themselves, the rank each student received dictated the next step in their education; high achievers were sent to study what were considered the most useful fields, while lower-ranked students studied subjects that were predetermined to be equivalent to their aptitudes.

"I was sent to Libya [North Africa] to study veterinary medicine," says Mohamed. "But that wasn't what I wanted to study. It took me one year to come to terms with that, but it was partly because of my ignorance." He recounts the fact that he was the first of his extensive family to attend university. The notion of a career path was entirely new, but having never left Mauritania before, specialist jobs such as veterinarians seemed incomprehensible and irrelevant.

"I would've preferred to study human medicine because from what I could see it

"I'm not rebellious. There just has to be a convincing argument for why I should do something."

had more purpose. I had no appreciation for veterinary medicine," he explains.

But by the time he graduated from his degree, Mohamed had developed a fresh respect for the discipline and the abundant knowledge and diversity in the world.

His return to Mauritania was tough. While he had breached a boundary and tasted a new life, the open wilderness he returned to seemed suddenly confining and restrictive. In a country without universities, employment prospects for veterinarians were unsurprisingly limited. What's more, he had experienced a domain in which questions were encouraged and new knowledge was not only pursued, but also created. He needed to know and see more, so decided to travel to a new country.

In 2000, five months later, after carefully examining his options and choosing his destination, Mohamed arrived in America. "At that time an American visa was easy to get hold of because few people were moving to the United States and there was a US embassy in Morocco. I also had to go to an English-speaking country because all my textbooks had been written in English."

But his plan was not to head straight for school. Instead, he found a job in a food processing company in Ohio County, Kentucky.

"My family was poor, so I didn't have lots of money to travel and I had to make it on my own," Mohamed says. He describes how he steadily built himself a new home and supported his new lifestyle independently, but emphasizes that he never accumulated money. "I always shared my money with my family." However, he says, he never surrendered his plans to study, something his family wholly supported.

"In my culture, people are valued for their characters and knowledge, not money and jobs," Mohamed says. "I always sent money home but it was not the main reason for leaving." He describes his family and explains that as one of thirteen children, he and his siblings all worked to help the family.

Constrained by money and commitments to work, Mohamed scrutinized his options for graduate school and eventually discovered a realm of online degree courses. He laughs when he considers his choice of epidemiology.

"It was never what I wanted to study. On my list, pathology was top and epidemiology was last," he says. "But online programs were rare and the first one I could find was in epidemiology with the London School of Tropical Medicine and Veterinary College, so I enrolled."

Accepting the lesson he had learned with his first degree, Mohamed believed the course itself would eventually reveal to him why epidemiology was a discipline worth studying. Unfortunately, the online tutorials and the convenience of studying at home soon proved problematic.

"I kept working while I studied but it was

Photography credit: Ahmed Mohamed

Photography credit: Ahmed Mohamed

just too difficult. I didn't have enough time and I was also away from the educational environment, so I wasn't motivated." Here, his tenacity kicked in. "I didn't want to stop in the middle, I wanted to see it through and see where I could go."

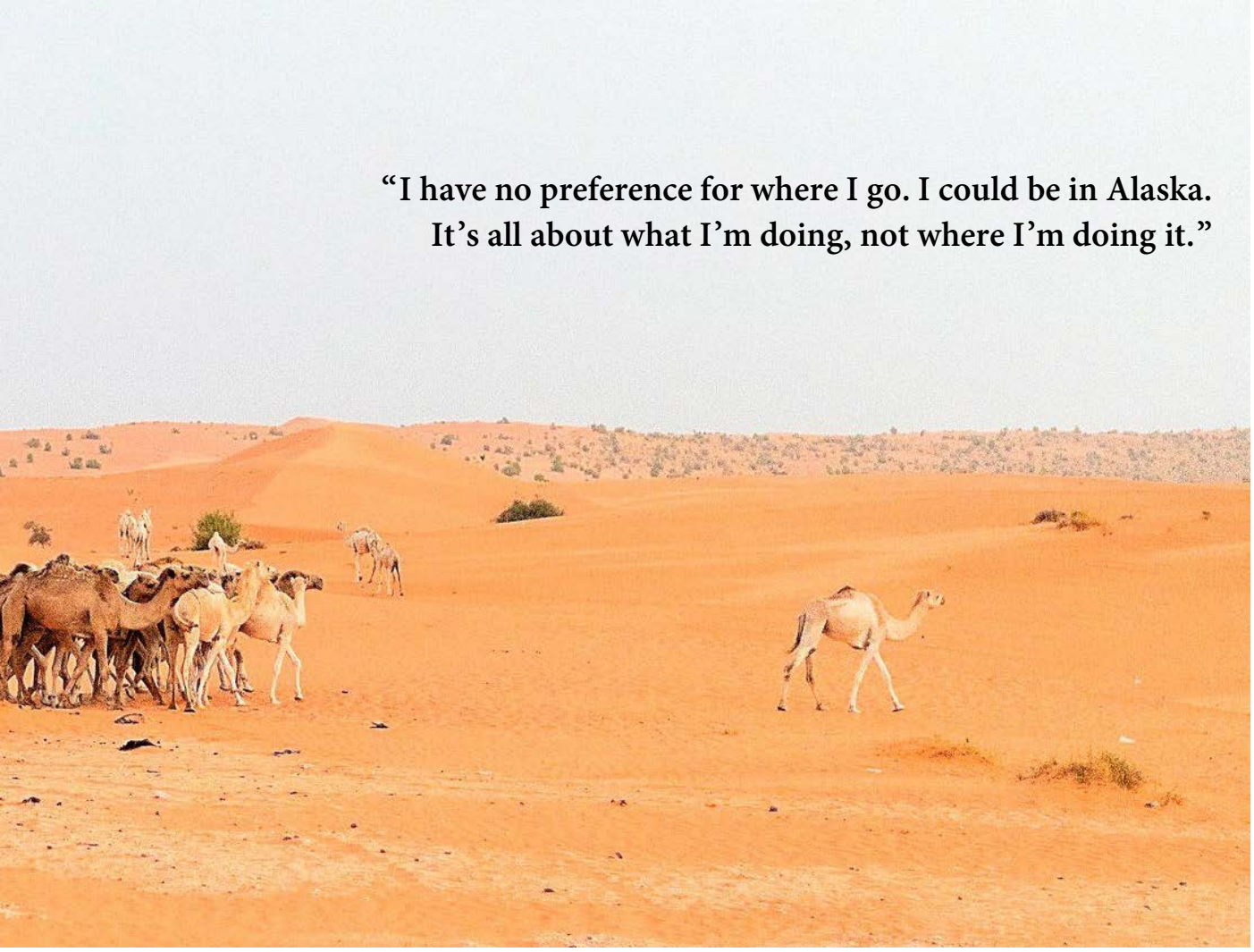
Resolved, Mohamed applied for a position on the full master's degree program and was accepted, and scooping up enough money to buy a plane ticket he flew to London and moved into the graduate students' halls of residence.

"It was another culture shock but I never feel attached to one place." Mohamed smiles contentedly as he thinks back to his time in London, particularly his location near Hyde Park, one of the Royal Parks, and all the other international students he met.

"Moving somewhere new comes naturally because I grew up moving from place to place. I never had an anchor." He contemplates his life now. "I still notice it. I have no preference for where I go. I could be in Alaska. It's all about what I'm doing, not where I'm doing it."

Though he was finally back at university and satisfying his thirst for knowledge, Mohamed remembers his studying to be fulfilling but difficult. Despite spending long enough in America to become a permanent resident before moving to London, English remained a challenging language. Though fluent, he found it tough to interpret the words and keep up with the pace of the teaching.

At this point in the story he smiles again. "In my culture we say two things. Never brag, and never feel sorry for yourself." Already embarked upon his degree, Mohamed saw the language barrier as a tall but conquerable



"I have no preference for where I go. I could be in Alaska. It's all about what I'm doing, not where I'm doing it."

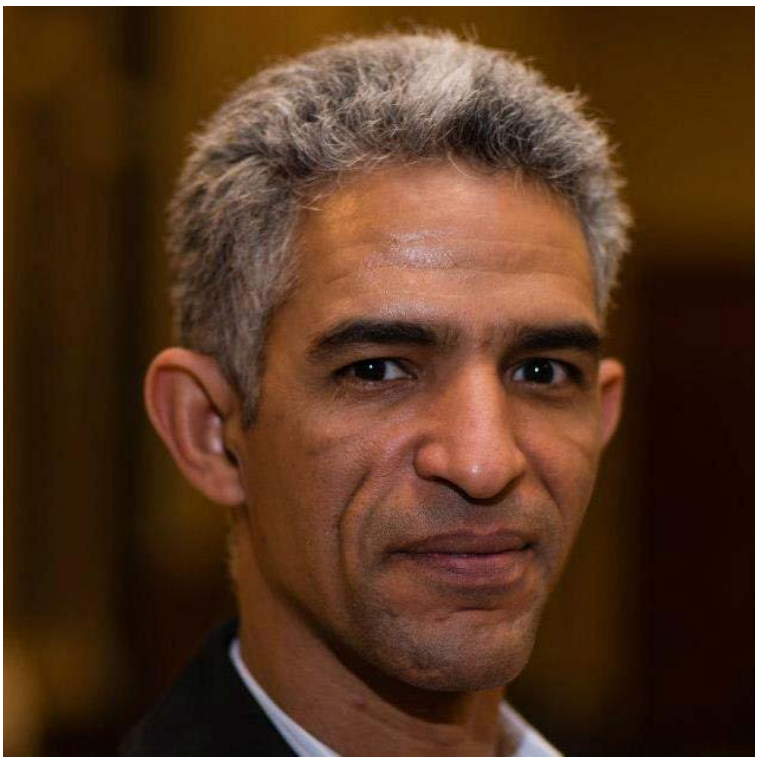
hurdle rather than an impassable problem.

With permanent residential status, Mohamed decided that moving back to the US after completing his master's degree was logical. In London his dissertation project had involved collaboration with Purdue University in West Lafayette, Indiana. Now armed with a greater appreciation for epidemiology, Mohamed decided upon a PhD in epidemiology at Purdue University.

"I have a lot of faith in my decision-making process. I don't accept anything by default, I arrive at each conclusion by myself." Mohamed laughs. "But I'm starting to realize there are drawbacks to that. The reality is that life is give-and-take, it's not black and white. Sometimes you can't explain everything and you have to go along with it."

Four years later after collecting his PhD, Mohamed stepped out of academia and accepted a job as a public scientist in the Department of Public Health (DPH) in Arizona. Although he had enjoyed academia he was intrigued by the huge potential that government work offered, and he was keen to put his training to good use.

"[In the DPH], that's where the decisions are made for situations like disease control," Mohamed says. But the new position soon aggravated his compulsion for informed decision-making. "There wasn't full intellectual freedom. It wasn't like typical research. The topics changed a lot and there was no focus. As soon as I started to learn about one thing the whole project would change. It was very different, very administrative. In the DPH there is a scientific basis for the decisions but the



Photography credit: Ahmed Mohamed

decisions were made without me." He nods his head decisively. "It was an excellent job with very good pay. But money was never the main factor."

So, in 2016, Mohamed reached a new conclusion and left the DPH for a research position at NC State University in the Department of Biological Sciences. Within two months he was convinced his decision to return to academia had been the right one.

"Here, I'm part of a research team. I can't do the whole of research on my own, but as part of a team I can focus on my own skills and actually progress," Mohamed says. "There are so many components of research that fit together to become good research."

He explains his satisfaction in team work. By being given the space and time to specialize further he forms an essential cog in a much larger and ever-advancing machine to answer more and more questions.

When I ask what motivates his research now, he pauses to think for a moment. "The big reason is so that at the end of it all we can say we did what we did to make a difference, to make people's lives different."

And the small reason?

"It goes back to my culture. If you're good at what you do, that says something. We value knowledge. I'm part of a community of epidemiologists and want to be a positive force and contribute to the field as an expert, and be a productive member."

He returns to considering his belief that money should never be the goal. "By being productive and making a difference, you will become successful and be compensated. That's why money must come last, because it will come at the end."

"Different people have different motivations, but I can't be motivated by money. For example, if I made a discovery that I could sell, I wouldn't charge money for it because this takes money away from other people. My net contribution will always be positive because I will always give without taking."

At the end of the interview Mohamed swings his bag onto his shoulders, unaware of the lessons he has just bestowed. Though many people value knowledge and character above money, the divide between these two values is typically blurred. A sharper contrast between such principles would surely make the world a better place.

Just before we part to make our way to our own cars I remark on his extraordinary achievements, perhaps the most impressive being his decision to leave home so he could go against the norm and draw his own conclusions.

I even suggest that these actions make him brave, but he shakes his head. That's not what it's about.

"We never feel sorry for ourselves and never brag," he reminds me, and then smiles, remembering something. "You know, I saw something written on a coat earlier today. It said '*The best way out is through*'. I think that's a pretty good motto." ▮

- Greer Hawkins

NC STATE

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Got a question?

Contact a member of NC State's Postdoctoral Association and we'll be happy to help.

Photography credit: Allen Watkin

Clint Penick

Illustrating insect diversity

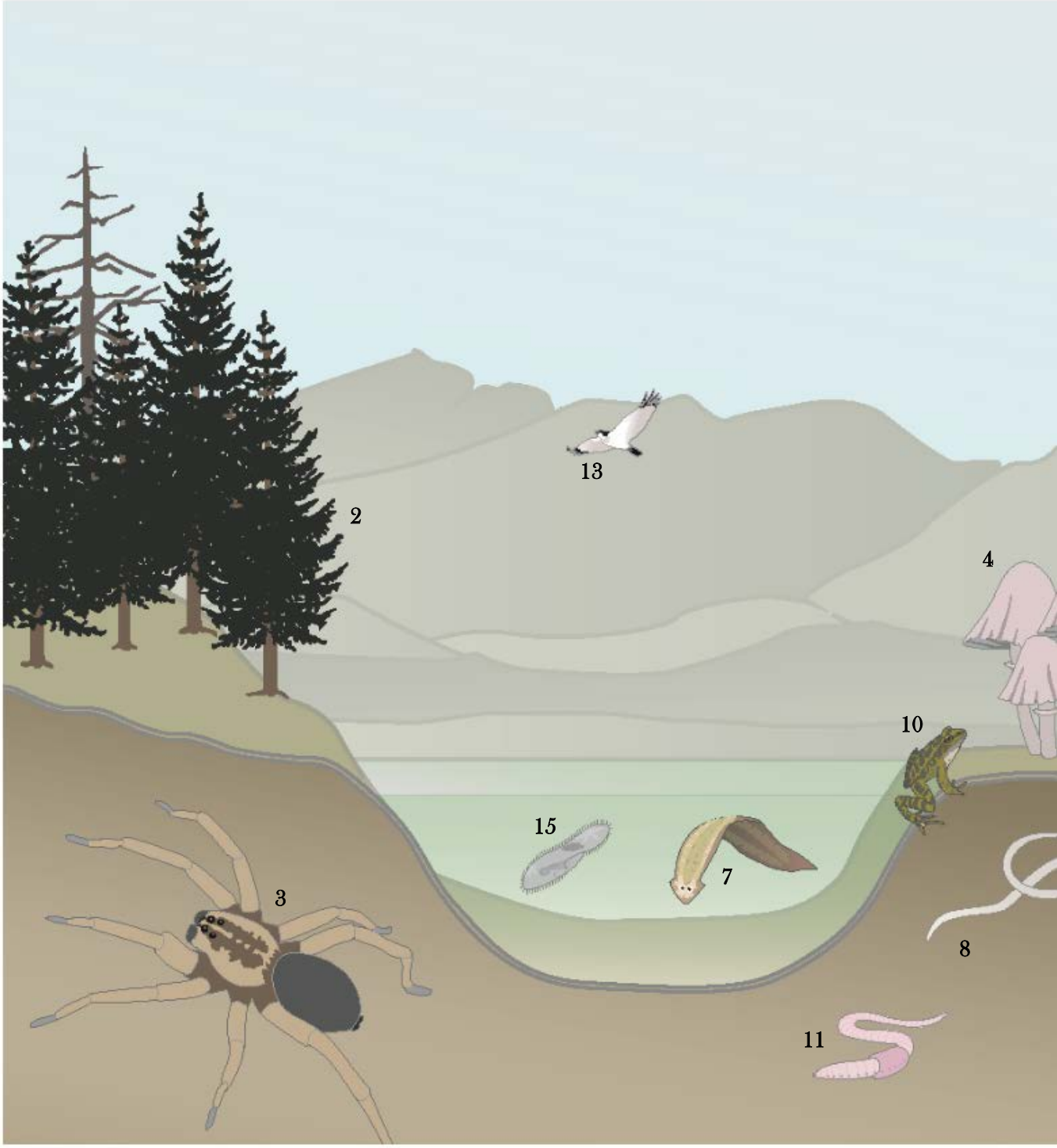
Clint Penick is a postdoctoral researcher in the Department of Applied Ecology at NC State University, funded by a National Science Foundation Math and Science Partnership grant under the supervision of Professor Rob Dunn. He received his undergraduate degree from Florida State University and his PhD from Arizona State University.

Penick's recent published work can be found in *Proceedings of the Royal Society B*, *American Entomologist* and *The American Naturalist*. His current research focuses on understanding the evolution and ecological success of social insects.

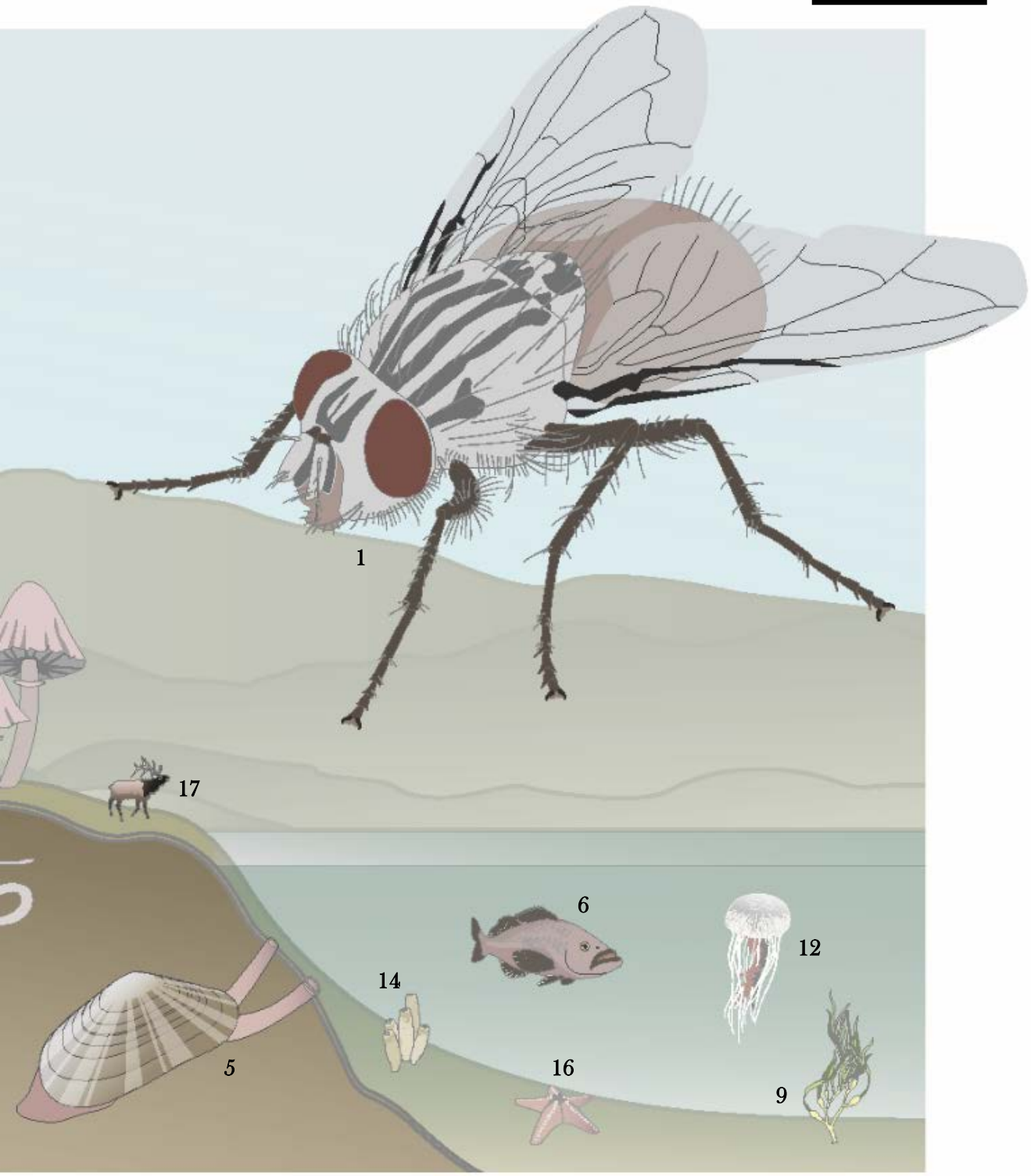
Counting all the insects in the world is no easy task. As one of nature's great success stories, not only are insects found absolutely everywhere, their numbers are gargantuan. Insects make up nearly half of all existing species and account for the largest portion of life on Earth. To date, over 1,000,000 insect species have been described—a staggering triumph over mammalian species, which number at a mere 5,898. To depict this remarkable diversity, my colleague Magda Sorger and I unveiled our update to the SPECIES SCAPE—a famous diagram of global biodiversity—at this year's International Conference of Entomology (ICE) in Orlando, Florida. Since insects comprise such an enormous proportion of life on this planet, our work on SPECIES SCAPE will hopefully serve as a poignant reminder that insects play a critical part in all environments and must therefore be protected.

Our SPECIES SCAPE is not the first. The project began when Quentin Wheeler, an entomologist, taxonomist and the current president of the State University of New York College of Environmental Science and Forestry, worked with Frances Fawcett, a scientific illustrator, to publish an illustration in *The Annals of the Entomological Society of America* in 1990. The illustration depicted trends in biodiversity and provided a direct comparison between multiple groups. In the original illustration and our update, different groups of species are represented by a chosen creature—in our diagram an elk represents all mammal species, while a fly represents all insect species. To provide perspective, the size of each creature is scaled according to the number of species within each group. For instance, the monstrous fly in our SPECIES SCAPE, which swamps almost a quarter of the page, conveys the fact that the number of insect species vastly outweighs the number of species in any other group. This contrasts with the animals people tend to think of most—birds, reptiles, fish, and mammals—which are represented by some of the smallest pictures in our SPECIES SCAPE.

In contrast to the original, our updated illustration contains several modifications. First, we considered several significant changes to taxonomy. For instance, since Wheeler and Fawcett's publication, "algae," a diverse group of aquatic organisms capable of photosynthesis, now no longer exists as a formal classification. Instead, algae have been divided into multiple and sometimes-unrelated groups. The largest of these groups is Chromista, which means "colored"—a reference to their characteristic brown-gold pigmentation—and was used to replace algae in our illustration. Second, we decided to totally exclude certain groups of organisms that were included in the original diagram such as bacteria. Decisions such as this were made because the number of bacterial



	Described species		Described species
1. **Insects**	1,053,578	6. **Fish**	32,834
2. **Plants**	422,000	7. **Flatworms** (Platyhelminthes)	29,487
3. **Non-insect arthropods**	203,462	8. **Roundworms** (Nematoda)	25,033
4. **Fungi**	100,000	9. **Chromista** (Algae and allies)	17,892
5. **Mollusks**	84,977	10. **Reptiles & Amphibians**	17,782



	Described species
11. **Segmented worms** (Annelida)	17,388
12. **Cnidarians**	10,183
13. **Birds**	10,055
14. **Sponges** (Porifera)	8,659
15. **Protozoans**	8,118
16. **Echinoderms**	7,550
17. **Mammals**	5,898

species is greatly debated and likely far more diverse than current numbers suggest. This is probably true for other classes as well, such as fungi, although we did include fungi in our update. Third, we limited ourselves to 17 major groups by setting a minimum threshold of 5,000 species per group. Although most species fell into groups that met this threshold, some of our favorite groups didn't make the cut, like the 1,167 species of tardigrades, water-dwelling micro-animals that resemble microscopic bears.

A tardigrade, more popularly known as a microscopic water bear.
Photography credit: Katexic Clippings Newsletter

After setting exclusion criteria, we also made decisions regarding the inclusion of different taxonomic levels. In our update we included the kingdoms of plants and fungi, but we split the animal kingdom into separate phyla and smaller groups like birds and fish. During this process we discovered that even some of these well-known groups were not as clear as previously thought. The word "fish" is actually a collective name for several distinct lineages, and their former class, Pisces, is no longer used in formal classification. Even crocodiles, it turns out, are more closely related to birds than to other reptiles, leaving some scientists to consider whether birds and reptiles should belong to a single group. However, we chose to maintain these common divisions since they are what most people commonly recognize. To emphasize the diversity of insects, we split them off from all other non-insect arthropods (invertebrate animals with a segmented body, an exoskeleton and jointed limbs) such as crabs and spiders. While insects were the clear winners in terms of extensive diversity, the remaining arthropod group still held a place just behind plants as the third most diverse group with over 200,000 species.

Despite intense study, current estimates suggest we have only catalogued 10 to 20% of all species, and even these estimations are generous. The discovery of new species endures today and is set to continue into the distant future. Consequently, our update of the SPECIES SCAPE is really a work in progress—a snapshot in time of the number of known species that will soon change again.

What is unlikely to change, however, is the dominance of insects. In 2009, only 41 new mammal species were described, a stark comparison to the 13,000 new species of arthropods that were reported, the majority of which were insects. We hope our update of the SPECIES SCAPE encourages more people to consider the role of insects in our world as well as our need to protect their diversity. Right now, there are nearly 12,000 species listed on the IUCN Red List of Threatened Species as "endangered" or "critically endangered," but only 4% of these are insects. Compared with larger, more charismatic animals, insects typically receive less attention from a conservation perspective, but their diversity suggests they are equally or perhaps even more important than other animal groups. Projects like SPECIES SCAPE can help raise awareness about how diverse insects really are and why they deserve our protection. ▮

- Clint Penick

This article was adapted from an article that was originally posted by www.yourwildlife.org.

Got something to say?

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Historical profile

Harold Hotelling

American mathematical statistician and economic theorist. Born in Fulda, Minnesota, in 1895, he died on December 26, 1973, aged 78 in Chapel Hill, North Carolina.

Photography credit: North Carolina Digital Collections via Wikipedia

In 1919, the same year that the United States Constitution established the prohibition of liquor, Guantanamo Bay was acquired as a naval station and the first electric pop-up toaster was invented, a young Harold Hotelling graduated from the University of Washington with a bachelor's degree in journalism. Less than one year later, having received encouragement from Eric Temple Bell, a Scottish-born mathematician who taught at the same university, Hotelling returned to academia to embark on a master's degree course in mathematics. By the end of his life, this significant switch in academic fields would eventually mark the beginning of an esteemed and influential career in statistics and economics.

Hotelling was born in Fulda, Minnesota, on September 29, 1895, to Clair Alberta Hotelling and Lucy Amelia Rawson. During his childhood the family relocated to Seattle, Washington, a decision driven, at least in part, by the success few the Ford Motor Company and its revolutionary production of the automobile.

In Seattle, Hotelling studied at the University of Washington until he completed his master's degree. In 1921, he travelled across the country to Princeton University, New Jersey, where he delved deeper into the realm of mathematics through his PhD. A principal focus of Hotelling's PhD thesis, entitled "Three Dimensional Manifolds of States of Motion", was topology, a complex yet fundamental mathematical topic that studies a flexible form of geometry.[1]

After graduating from Princeton University in 1924, Hotelling worked as an associate professor at Stanford University, California, but soon broadened his gaze to a new arena known as statistics. Despite often being associated with mathematics, statistics is an altogether distinct discipline with uniquely useful qualities. As described by John Wilder Tukey (1915-2000), an American mathematician well known for his contribution to the field, "statistics is a science, not a branch of mathematics, but uses mathematical models as essential tools".[2]

Bibliographies of Hotelling's extensive work and publications can be found in
Olkin I, Ghurye S, *et al.* In: Mathematics of Computation, 1961. Volume 15, no. 74. Published by American Mathematical Society.

The primitive origins of statistics can be traced back to remarkably antiquated beginnings, as early as around 450 BCE when Hippias of Elis, a teacher of philosophy in Ancient Greece, calculated the date of the first Olympic Games by averaging the length of reigns of previous Grecian kings.[3] Since then, across centuries, empires and dynasties, statistics was and still continues to be refined as an invaluable analytical tool.

In search of further training to pursue his new interest in statistics, Hotelling left Stanford and travelled to an agricultural research station in Rothamstead, England, in 1929.[4] Here, Hotelling studied for six months with Sir Ronald Aylmer Fisher (1890-1962), an English statistician and biologist famous for his work in population genetics. Fisher's well known work also included the application of mathematics for the integration of genetics with natural selection. Upon returning to the mathematics department at Stanford, Hotelling began to apply his newfound techniques in various fields including journalism, food supply and political science.[5] In addition to his statistical work, during the 1920s and 1930s Hotelling also made a substantial impact on various economics topics, including game-theory and depreciation.[5] His work on depreciation became particularly influential; his incorporation of mathematics in economic reasoning surpassed traditional methods and set a new standard for the field.[4]

In 1931, Hotelling obtained a professorship at Columbia University, New York, in the Department of Economics, a position he retained until 1946. As well as teaching mathematical economics here, Hotelling developed a statistics teaching program and eventually founded a department of statistics. Together with Burton Camp and Arthur Robert Crathorne, both professors of mathematics, Hotelling also founded the Institute of Mathematical Statistics.

In 1937 Hotelling was elected Fellow of the American Statistical Association, of which he also served as vice president in 1941. During World War II, alongside Wilson Allen Wallis (1912-1998), an American economist and statistician, and Jacob Wolfowitz (1910-1981), a Polish-born American statistician, Hotelling worked as a charter member of the Statistical Research Group and contributed his statistical expertise to the war effort.

After the war ended, Hotelling left Columbia University to begin a new chapter at the University of North Carolina (UNC) at Chapel Hill, North Carolina, in 1946. Here, Hotelling worked with Gertrude Cox (1900-1978), an American statistician and first woman elected into the International Statistics Institute, to found a faculty of statistics.

During his time at UNC-Chapel Hill, Hotelling was a professor and chair of the Department of Mathematical Statistics, a professor of economics and associate director of the Institute of Statistics. Hotelling received a promotion to Kenan Professor of Statistics in 1961. Five years later in 1966, Hotelling retired and in 1972 received the North Carolina Award for Contributions to Science.[6] In 1973, Hotelling died in Chapel Hill. In honor of his revered career and pioneering work, UNC created the Harold Hotelling Professorship in Economics in 1989.

The vast quantities of publications Hotelling wrote and contributed to are a mere fraction of his legacy. Often referred to as a pioneer of mathematical statistics and economics, Hotelling and his life's work not only had a profound effect on these fields, but also on the establishment of statistics as a science. By founding and supporting different organizations and departments, Hotelling ensured that his work would have a lasting impact, and by building solid foundations, allowed the science of statistics and economics to evolve and flourish. ▮

- Greer Hawkins

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