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behind the science

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Verve

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Cover image: Fluorescent microscopy image of a heart cell infected by a virus, by Efrain Rivera-Serrano (page 25).



Verve

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From the Dean



Dear NC State Postdocs,

Welcome to our first ever NC State postdoc magazine, Verve! I hope you will find it informative and that you will continue to share your experiences with us. You are part of a vibrant group of research scholars, and the Graduate School is proud to participate in your professional and career development, as the home of NC State's Office of Postdoctoral Affairs.

You have picked a fantastic place to do your postdoctoral work. We are uniquely situated in a research rich environment, with high-impact research, technology and innovation all around us. I encourage you to become active participants in the university community - we welcome your ideas and collaboration.

This is an exciting time to be at NC State. Our postdocs have gone on to become faculty research scholars, entrepreneurs, industry leaders, and government and non-profit directors. As postdoctoral scholars, you possess the skills to grapple with the serious issues and problems facing our world. Your advanced training in science, communication skills and critical thinking make you all valued members of this community.

Best of luck on your postdoctoral journey!

Sincerely,

*Dr. Maureen Grasso
Dean of the Graduate School*



Welcome to Verve

Dear Researchers,

It is my very great pleasure to introduce you to your new magazine, *Verve*, written by and produced for the postdoctoral researchers of NC State University. You might be surprised to know that we are, in fact, few in number. There are about 400 postdocs here at NC State, a relatively small community in comparison to many of the big postdoc powerhouses found elsewhere in the United States.

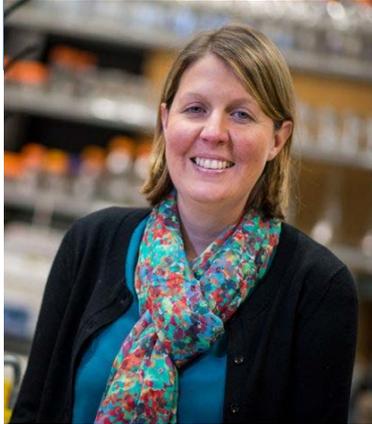
But this small size has not served NC State any disadvantage. In fact, NC State's postdoctoral scholars remain a notable force of research, capable of producing high quality data across a spectacular variety of disciplines, ranging from entomological projects on insect biodiversity to agricultural research exploring the impact of soil microbes on tree growth; and from molecular biology projects studying the genetics of allergic disease to computer engineering research of 3D integrated circuits.

Although we typically display our research achievements as formal, hard-won publications in various national and international journals, it seemed that it was about time we stepped outside of our own departments, out from the intensity of our own highly individualistic projects, and immersed ourselves the intriguingly diverse research we achieve here at NC State.

The intention of *Verve* is to acquaint you with your researcher neighbors and their work, who too are embarking on an indisputably challenging career path. Anyone who has or is currently working as a postdoc has great respect for the tenacity required to maintain this data-driven and teaching-intensive job, but is also acutely aware that these jobs are never static – the postdoc world is an unendingly fluid one, full of obstacles and difficulties. and one that takes no small amount of willpower and a sprinkling of luck to navigate through. For this reason, *Verve* also intends to discuss and tackle many of the issues that postdocs face, and hopefully become a useful source of advice, support and illumination.

- Greer Arthur
Editor in Chief of Verve

THERIOT EARNS NIH GRANT TO FIGHT BACTERIAL INFECTIONS



The National Institutes of Health has awarded a \$1.5 million grant to Casey Theriot for research combating one of the leading hospital-acquired infections in the United States.

Theriot, an assistant professor of infectious disease at North Carolina State University College of Veterinary Medicine's Department of Population Health and Pathobiology, is exploring new bacterial therapies to treat *Clostridium difficile* infections, which affects more than 500,000 and leads to the deaths of 30,000 Americans each year.

"This award will allow [my research lab](#) to continue to search for the mechanisms of how the gut microbiota provides resistance against pathogens including *C. difficile*," says Theriot.

- Jordan Bartel

For the full story, visit: <https://cvm.ncsu.edu/theriot-earns-nih-grant-to-develop-bacterial-infection-therapies/>

For more stories, visit: <https://news.ncsu.edu/>



Photography by Nicolas Nova

RESEARCHERS FIND VULNERABILITIES IN APPLE'S IOS

An international team of computer science researchers has identified serious security vulnerabilities in the iOS – the operating system used in Apple's iPhone and iPad devices. The vulnerabilities make a variety of attacks possible.

"There's been a lot of research done on Android's operating systems, so we wanted to take a closer look at Apple's iOS," says William Enck, an associate professor of computer science at North Carolina State University and co-author of a paper describing the work. "Our goal was to identify any potential problems before they became real-world problems."

"We are already discussing these vulnerabilities with Apple," Enck says. "They're working on fixing the security flaws, and on policing any apps that might try to take advantage of them."

The paper, "SandScout: Automatic Detection of Flaws in iOS Sandbox Profiles," will be presented at the ACM Conference on Computer and Communications Security, which is being held Oct. 24-28 in Vienna, Austria. Lead author of the paper is Luke Deshotels, a Ph.D. student at NC State.

- Matt Shipman

For the full story, visit: <https://news.ncsu.edu/2016/08/vulnerabilities-in-ios-2016/>

PSYCHOLOGY PROFESSOR RECEIVES APA AWARD



Psychology professor Tom Hess will receive the American Psychological Association's most prestigious award for research on adult development and aging. The award, sponsored by the Margaret and Paul B. Baltes Foundation, recognizes researchers with distinguished careers of exceptional theoretical and empirical contributions to the psychological science of aging.

- Nash Dunn

For the full story, visit: <http://news.chass.ncsu.edu/2016/07/11/a-pa-honors-psychology-professor-with-distinguished-research-award/>



CELEBRATING 50 YEARS

As Carter-Finley Stadium celebrates its 50th anniversary as the home of Wolfpack football, fans and alumni are reflecting on all the great moments they witnessed during the facility's first half century, from extraordinary upsets on the gridiron to the Billy Graham Crusade to the international broadcast of the Special Olympics Opening Ceremonies.

- Tim Peeler

For the full story, visit: <https://news.ncsu.edu/2016/08/home-moments-to-remember/>



Learning the
language:

Harnessing
plant
communication
to feed the
world



Jeremy Heath is a postdoctoral fellow in the Department of Entomology and Plant Pathology at NC State University, funded by the National Institute of Food and Agriculture. He received his undergraduate degree from Acadia University in Canada, his Master's degree from Ohio State University, and his PhD from Wright State University in Ohio.

Heath's published work can be found in *New Phytologist*, *Ecological Entomology*, *Arthropod-Plant Interactions*, *Entomologia Experimentalis et Applicata*, *Plant Disease*, *Environmental Entomology*, and the *Journal of Chemical Ecology*. His current research focuses on exploiting the biochemical mechanisms of plant communication to improve worldwide agriculture and food production.

The relentless increase in the human population has placed huge demands on worldwide food production. To make matters worse, climate change is creating a hotter and more variable environment, intensifying further the chronic difficulty of growing sufficient food. Although recent projections predicting that the human population will stabilize at around 8 to 10 billion by the year 2100 are encouraging, a more efficient system of food production is still needed if the persisting food shortages are to be addressed. In response to the shortage numerous solutions have been tested in an attempt to increase the yield of food. But although important improvements have been made over the years, the proposed solutions are not straightforward and are often riddled with complications.

One approach that has already been implemented is the manipulation of agricultural systems to achieve an increase in food production beyond what would be naturally possible. The Green Revolution, an ambitious program during the middle of the last century designed to inflate crop yields worldwide, achieved this by increasing fertilization and irrigation, distributing newly developed crop varieties with higher yields, frequently using pesticides, and broadening the use of agricultural machinery. The overall aim of these improvements was to simplify the agricultural system, which would ostensibly make it more manageable. Although the goal was achieved to some extent, the solution was not flawless.

The simplification instigated by the Green Revolution resulted in the drastic reduction or complete loss of essential insects and pollinators, as well as a sudden rise environmental and human health issues. Since analyzing the

repercussions of the Green Revolution, scientists and the public have become increasingly aware of the indirect negative impact that large-scale mechanized agriculture has on the environment. As part of the response to this, the perceived and real adverse effects of pesticides on both human health and the environment have led to environmental advocates stepping up the pressure by campaigning for the avoidance or discontinuation of unnecessary pesticides, especially in the developed world.

As important as this is, however, the advances achieved during the Green Revolution cannot be completely abandoned - this would risk thwarting agricultural improvements in underdeveloped countries. Instead, more efficient and environmentally benign agricultural technologies must now be developed, optimized and enforced, which will hopefully allow developing countries to leapfrog the tried-and-tested, and potentially damaging, tools. This is a huge challenge, and one that will involve pursuing many avenues of inquiry while retaining as priorities the increase of food production, safety, nutrition and health.

The circumvention of artificial pesticides might feel like applying a brake to the agricultural improvements already achieved, but have no fear. Plants are remarkable organisms. Despite lacking the same sensory organs possessed by animals, plants are capable of perceiving the same range of sensations: taste, touch, hearing, sight and smell. This sensing ability is utilized by the plants in many ways, including communicating with their own extremities and appendages, as well as



with their neighbors. One particularly useful example of plant communication is their ability to initiate a warning system. When under attack by a pest, plants respond with a flood of their own naturally produced pesticides. Impressively, neighboring plants that are not being fed upon can “smell” their neighbor’s pesticidal response and initiate their own defensive chemical production before the pest reaches them.

As another form of protection, some plants also synthesize biochemical rewards and odors to attract beneficial insects such as ants and parasitic wasps. These insects act as the plant’s own personal bodyguards against pests and parasites and also fulfill vital roles as invaluable pollinators.

In terms of developing new solutions to agriculture problems, plant productivity can potentially be increased by harnessing this “chemical ecology” to manipulate plants into producing more food, while concomitantly reducing the use of artificial pesticides. By taking over a plant’s natural defense systems we can take the decision-making away from the plant and switch their defense responses either on or off whenever we decide it is appropriate.

Today, in a world experiencing large fluctuations in climate, protecting plants from pests is not the only challenge of food production. A significantly larger and potentially more crippling problem is climate change, and breeding new varieties of plants that are drought tolerant, for instance, is no longer sufficient. Yields of plant growth and food production must be maintained at a high level, but with the advance of climate change, plants must not lose their crucial ability to adjust to an increasingly hotter and unpredictably variable environment. While plants have a capacity to adapt rapidly to environmental change, something they do innately each growing season, excessive breeding and the narrowing of gene pools to select for crop

varieties with specific traits, suitable for precise environments has meant that a lot of this adaptive flexibility has been lost. Finding a solution to this problem is challenging, but here also, harnessing plant communication could play a significant role.

Many of the chemicals that plants use to communicate exist in two very similar states. Some chemicals evaporate from the tissue and are transported in the air, while others flow through the “veins” of the plant, exerting various hormonal effects. These hormones are functionally no different to those found in animals; the hormones act as signaling molecules to control a huge variety of physiological functions. For instance, plant hormones regulate the immune system, growth and reproduction, nutrient allocation and escape mechanisms, to name but a few. Importantly, the airborne and soluble states in which plant hormones exist are interchangeable; a plant hormone can be released as a spray of airborne particles, travel by air to the plant, and upon contact can enter the plant and be converted into the soluble form for fluid transport around the organism. By exploiting this biological phenomenon and treating plants with specific airborne hormones, we hope to control the various functions of the plant whenever we need to. For instance, during the best weeks of the growing season we may want to encourage plants to allocate more of their limited resources to making seeds, which could later be harvested. Correspondingly, during the tough weeks, months, or years we may need to push plants into increasing their pest defenses or water conservation mechanisms to obtain any harvest at all.

This new method of manipulating plant behavior and growth is a potentially powerful agricultural tool that could sidestep many of the existing complications caused by traditional crop breeding, and in this critical age of extreme climate change, helping plants cope with variable environments is more important than ever. My first investigations into these ideas are currently underway, and I hope to report back on my results in a following issue of **Verve**. Stay tuned. ■

- Jeremy Heath

The Carmichael Complex



FIND
YOUR
FOCUS

Photography by Jeff Blackler

When postdocs are caught in the never-ending cycle of research and teaching, personal fitness and wellness are often the first lifestyle components to be abandoned. Yet the time spent taking care of one's body and disconnecting from work can be invaluable tool for enhancing productivity and improving quality of life. **THE CARMICHAEL COMPLEX**, run by University Recreation, offers a vast and engaging range of opportunities suitable for all needs to help researchers and students stay active and healthy.

University Recreation offers fitness opportunities for absolutely every interest and ability level. Most facilities can be found at the Carmichael Complex on Main Campus, which includes the Carmichael Gym, Carmichael Recreation Center, the Aquatic Center and Miller Field, as well as training fields and a disc golf course on Centennial Campus.

RECENT RENOVATIONS at Carmichael Gym have included an expansion of the front weight room and aerobic area, the addition of brand new equipment and the installment of brand new locker facilities.

For those researchers who prefer a solo, unsupervised workout, there are aerobic and strength training equipment facilities available in both the Carmichael Gym and the Recreation Center. Individuals who draw motivation from others can choose from more than **GROUP FITNESS CLASSES**, ranging from



investments in equipment.

Thanks to Heather Gately (hgately@ncsu.edu),
Member Services Coordinator for University
Recreation, for this information

*To learn more about the amenities offered through
University Recreation, or for more information on
how to obtain a membership, visit them at:*

<https://recreation.dasa.ncsu.edu>

Postdocs are eligible for a **TEMPORARY EMPLOYEE MEMBERSHIP** at a rate of **\$25 PER MONTH**. Memberships can be purchased at the Member Services Suites, located on the first floor of the Carmichael Gym.

TO APPLY, postdocs are required to present their Wolfpack One ID, along with a letter from their sponsoring department that displays their name, staff ID number and start and end dates of their research appointment. With membership, postdocs have access to all Carmichael Complex families and amenities, including services such as equipment checkout, personal trainers, private swim lessons and entry into intramural sports leagues.

HOUSEHOLD MEMBERSHIPS are also available for purchase by postdocs. Each postdoc can sponsor up to two household members (spouses, partners, etc.) for members the same rate own (\$25/mo).

Carmichael EX offers Family Recreation Hours (every weekend beginning Friday at 5:00 P.M.), during which time members can bring their children who be under the age of 18, to enjoy the pools.

Postdoc Overtime



The New Rule

As of December 1st 2016, any postdoctoral researcher employed in the United States, earning less than \$47,476 and working more than 40 hours per week will be entitled to overtime pay.

But what are the specifics of this new rule, and what are the potential consequences of raised postdoc wages on both the scholars themselves and the research industry?

On May 18th 2016, the United States Department of Labor made a momentous change to the lives of more than 4 million workers by raising the salary threshold for overtime pay. The new Fair Labor Standards Act (FLSA), nicknamed the “Overtime Rule”, is due to be implemented on December 1st 2016 nationwide, and is intended to provide clearer and improved protection for workers already entitled to overtime pay. One of the more conspicuous groups to be affected are postdoctoral researchers, whose atypical working pattern often makes calculations and compensation of overtime extremely difficult. So what are the specifics of the new rule, and how will the change impact postdocs?

As a government-decreed legislation, the FLSA controls overtime pay by dictating that all United States’ workers be paid 1.5 times the standard hourly wage for overtime work. Overtime is qualified as a week comprising more than 40 hours of work, a duration which is often noticeably surpassed by postdoctoral researchers. Seen as a workers in training rather than typical employees with regular shift patterns, postdocs often succumb to the demands heavy overtime, with little or no effort made by employers to keep track of the number of hours worked each week.

In addition to their overtime slipping by unnoticed, postdocs inadvertently meet other criteria that exclude them from overtime pay. As well as setting an hourly threshold of 40 hours per week for overtime pay, the FLSA also controls whether overtime is received by enforcing a precise salary threshold. If the

salary falls above an established threshold, the worker is not entitled to compensation for any overtime. The current overtime salary threshold in the United States, which was originally set over 10 years ago and has not been adjusted since to match subsequent financial inflation, is \$23,660 per year. Since postdoctoral salaries vary greatly, with the majority of postdocs earning an average of \$45,000, this makes most postdocs exempt from overtime pay.

However, as of December 1st this year, the new salary threshold will be \$47,476. Accordingly, this means that any postdoctoral researcher employed in the United States, earning less than \$47,476 and working more than 40 hours per week will be entitled to overtime pay. There are only a few exceptions to the new rule; postdocs with a primary teaching duty, for instance, are not covered by the new salary threshold, so will not necessarily be affected. Similarly to teaching postdocs, House Officers such as those at NC State’s College of Veterinary Medicine, who are considered medical professionals, will also be exempt, regardless of salary, and will continue to be treated as a population with policies separate to postdoctoral policies. However, certain individual institutions may decide to include teaching postdoctoral scholars in the threshold increase to allow all postdocs to benefit from the new Overtime Rule.

“‘Teaching’ is one of a small handful of occupations which is considered automatically exempt from the new FLSA,” says Siarra Dickey, Manager of Graduate Appointments,

“As of December 1st 2016, any postdoctoral researcher employed in the United States, earning less than \$47,476 and working more than 40 hours per week will be entitled to overtime pay.”

Fellowships and Postdocs at NC State University. “But at NC State, although no final decisions have been made, we are seeking resolutions that will avoid treating our teaching postdocs differently to our research postdocs, which is in line with our current practices”.

By raising the salary threshold, the new Overtime Rule will offer a different but narrow selection of options to employers. Making a choice between these options is mandatory for every Principal Investigator (PI), or faculty advisor, and institution that employs postdocs, and the decision must be reached and enforced from December 1st, 2016. Importantly, to a certain extent, implementation of the new FLSA is made at the discretion of each individual PI and their postdoctorate. Consequently, it is fundamentally imperative that postdocs also accept and adhere to the new Act, and do not avoid reporting overtime in their timesheets to circumvent the receipt of overtime pay.

To acquiesce to the new FLSA, employers can either increase the salaries of their postdocs to meet the threshold level, such that they no longer qualify for overtime pay even if they work more than 40 hours per week, or they can track the overtime undertaken by postdocs and pay the required time-and-a-half wage. Additionally, employers have the option of restricting postdoctoral work to 40 hours per week – but with research notoriously demanding excessive workloads, employers are less likely to choose this route.

“The current options at NC State are to increase the postdoctoral scholar’s salary, or track each postdoc’s working hours using a timesheet just like other full-time research appointments already use,” says Dickey. “There has not yet been a University-wide ruling, but at NC State we are encouraging departments and colleges to increase the salaries of their postdocs to meet the new threshold of \$47,476 rather than track overtime. We have already

started to see some departments rise to this challenge. If postdocs have questions or concerns, we would encourage that they talk to their faculty mentors and departments.”

In the current economic climate, with research still tentatively recovering from financial shortages and cutbacks, there has been understandable concern nationwide about how cost-effective this change will be and how much the salary increase will drain already depleted institutional funds. Whether the transition will be completed smoothly is also debatable; with the deadline of December 1st fast approaching, research institutions have had little time to adjust their budgets. There has also been rational speculation about the potential influence the new threshold will have on the length of secured employment. Research grants are finite sums of money, with specific quantities intended to cover the project duration allocated to employee salaries as well as research expenses. If postdoctoral salaries are to suddenly soak up a greater portion of the grant, it surely follows that either the project duration or money spent on research activities will be diminished.

“There is of course concern that a salary increase means postdocs will find themselves out of work sooner, simply because the raised salaries will eat through the grant at a faster rate,” says Dickey. For postdoctoral researchers looking towards their next position, the salary increase also threatens to diminish new funding after their current grant ends. “There will be an adjustment period,” says Dickey. “But we do expect postdoc positions to rise up again. It is our perspective that new grants will be better prepared for this change in salary expectations for postdocs.”

As a federal ruling from the Department of Labor, implantation of the FLSA is non-negotiable. “Administratively this will be challenging,” continues Dickey. “There will be a major culture shift in the research population, but the Office of Postdoctoral Affairs fully

“There has been understandable concern nationwide about how cost-effective this change will be and how much the salary increase will drain already depleted institutional funds.”

supports this law because it will ensure fair pay for postdocs, who we all know work very tough, long hours.”

Despite coherent concerns, NC State’s support joins a chorus of backing from frontrunners of research and labor laws. In an article published by the *Huffington Post*, Francis Collins, Director of the National Institutes of Health (NIH), and Thomas Perez, United States Secretary of Labor, quelled apprehensions by giving their own reasons as to how the change will be a positive one for postdocs and the future of academic research. According to Collins and Perez, it is widely acknowledged that current postdoctoral salaries do not satisfactorily reflect the researchers’ education, experience and knowledge. To try to correct this imbalance, the NIH has already been driving a steady increase in postdoc salaries.

“We are confident that the issues coupled to the increase in postdoc salaries will be short-lived,” says Dickey. “We have had positive feedback from the NIH and the National Science Foundation (NSF), both leaders in grant funding.” As well as allowing re-budgets on current grants, the NIH and NSF are evaluating potential changes to new funding; grants will be increased to compensate for the rise in salary.

Another related issue that the new FLSA is likely to help solve is the ever-expanding growth of the postdoctoral population. This problem is thought to have been driven by a combination of funding cutbacks, leading to fewer permanent, faculty and tenure-track vacancies, and continuous stream of PhD students being fed into academia, who eventually have limited career options. According to Collins and Perez, increasing the salary threshold will encourage an even greater influx of graduate students onto the postdoctoral path. While it is undoubtedly agreeable to see postdocs being rewarded for their hard work, will this salary increase help solve the problem of the postdoc bubble?

“There are many pieces to this specific problem,” says Dickey. “But ultimately the salary increase will only improve the quality of research. As funding sources react and grants compensate for the change, better opportunities will be created for postdocs and the recruitment of excellent researchers will continue.



In a discussion with *Nature* earlier this year, Benjamin Corb, Director of Public Affairs at the American Society for Biochemistry and Molecular Biology (ASBMB), stated that he believed increasing the salary threshold could help the research system recover. By making postdoctoral researchers more expensive, they will no longer be “seen as a cheap substitute”. Although the number of postdoctoral positions may diminish as research institutions adjust to the change, permanent staff scientist positions could appear and provide an alternative, more stable employment option to both institutions and their researchers. In this manner, the postdoc population could be streamlined without causing unemployment.

Inevitably, as with the arrival of any change, the long-term impact will be unpredictable, but the acute effects will be felt most strongly by current postdoctoral scholars. Importantly, although concerns about the new Overtime Rule exist, the ensuing changes, both distant and near, will hopefully be positive and force a much-needed reorganization and reformation of research. For all their hard work and experience, the salary increase for postdoctoral researchers has been long overdue. Adjustment will take time, but the new FLSA will ultimately and rightfully increase the wages of some of the hardest working personnel in academic research. ■

- Greer Arthur

If you have any questions about the new FLSA and how it affects you, contact Laura Demarse (ledemarse@ncsu.edu) or Siarra Dickey (sydickey@ncsu.edu).

For access to more information about the new FLSA, visit:
<https://www.dol.gov/sites/default/files/overtime-highereducation.pdf>

**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

Into the Bottleneck

A brutal fact of academic life is that there are a too few permanent positions available for the legions of postdoctoral researchers fighting to fill them. The result is a bottleneck, and for the vast majority who do not manage to trickle through to the next stage of their career, staying stuck in a postdoc bubble seems like the only other option. Is it right to ever accept defeat and leave?

By the time you make it through your thesis defense examination and hear that you have passed, tumbling headfirst into a new project as a postdoc feels like a refreshing new start. Your brain is still bustling with the mistakes and frustrations of your PhD – but it’s OK. This time you are well prepared. You have learned from the multitude of lessons that your last degree had to teach you and you know precisely what you are here to do. The academic career path that lies before you looks challenging, but your foot is on the road and you can see a straight line to the next stage. What could stop you?

Fast forward to a few years later. Suddenly that route is not quite so arrow-straight. In fact, it’s starting to curve into more of a ring-road, making it hard to see whether you have made it much further along than where you first began. As time moves on, you become consciously aware that your career momentum is dissolving and you risk getting trapped in a sticky postdoc cycle.

This experience is by no means a singular one. In 2009, Sheldon Schuster reported that according to the National Institutes of Health, 42 was the average age for researchers to obtain first-time grants¹ – strong evidence for the severe limitations preventing career advancement through academia. Today, influential publishers such as *Nature*, *Times Higher Education* and *Science* discuss continually the clog in the postdoc system and the impenetrable mass of contributory problems. While more PhD students are fed into the system, a combination of poor economic climate and severely limited tenured and full-time faculty positions has caused the postdoctoral population to swell.² In biology research in the US in 2012, only 15% of PhD students migrated into tenure-track faculty positions within 6 years.³⁻⁵ According to other studies, fewer than 10% of PhD students obtain tenure-track faculty positions,² and despite being aware of the small chances of achieving a faculty appointment, many graduate students move into postdoctoral positions anyway.⁶

As the problem compounds, institutions have proposed solutions such as rearranging laboratory structures and increasing the number of permanent staff.⁷ Additionally, it still remains predictable that a researcher will fulfill a postdoctoral appointment if they intend to pursue a full-time career in academia. If newly graduated PhDs were presented with options other than the postdoctoral default, for instance, this could release some of the building pressure.

The Maze

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“For postdocs today, taking up a position in the ever-expanding queue for tenure-track and permanent positions seems inevitable”

But for postdocs today, for whom any solution remains dismayingly distant, taking a place in the ever-expanding queue for tenure-track and permanent positions seems inevitable. For those of us in line right now and waiting for something that might never happen, is it right to give up and jump ship?

The notion of giving up a PhD is one of the first barriers against leaving academia. Years of hard work, stress, long hours and frequent sprinklings of emotional turmoil make the degree something to be proud of and hold on to. Without the challenge of daily research, everything you have learned so far would surely go to waste.

What's more, an exit from academia feels like slipping back down the career ladder to somewhere unknown – a huge and incalculable risk. You'll be competing against fresh-faced, cherry-cheeked graduates energetically springing out from their undergraduate degree with an up-to-date view of the job market. For you, the last few years of your life have been spent in research, not fluffing up your CV with employer-enticing morsels. The outside world is not run by a currency of papers, publications and grants, so your job-hunting and interview toolkit appears ill-equipped and useless.

Finally, even if you do take a wary glimpse of jobs on a search engine, you have absolutely no idea what to look for. Titles such as "Project Manager", "Principal Scientific Officer" and "Operations Manager" seem generic and dreadfully unfamiliar. Every vacancy also seems to be routed through a recruitment agency, making you feel even more disconnected from your potential interviewer. The postdoc bubble might be frustrating and exhausting, but at least it is familiar.

An essential part of survival is recognizing when it is time to let go, and a vital part of allowing that to happen is recognizing that it is not necessarily a bad thing to do. A career switch seems frightening, but any change takes time, and trying something completely different is never pointless.

Leaving the academic route is not something that all postdocs should do, of course. Those determined enough to reach permanent faculty jobs are under no illusions that this will be easy, and know long hours and repeated letdowns lie ahead. But postdocs without this burning desire to persist are a far cry from failure, and are by no means unsuitable for science and research. Research provides an exemplary platform for problem-solving, and is a highly sought after skill to have mastered. The field in which postdocs learn this proficiency is, for the most part, inconsequential, and the very nature of this ability allows them to adapt to any future situation. Few arenas other than research teach individuals how to think, critically assess and troubleshoot to such an extensive degree. In research, it quickly becomes impossible and insufficient to be spoon-fed knowledge.

With this in mind, suddenly your interview toolkit does not seem quite so impoverished. There is more to research than churning out data and papers, and although postdoc positions have been described as "holding positions" for people who have yet to choose a career path,⁸ time spent in a postdoc can still provide valuable training. While your publication list may not have the same weight outside academia, as a researcher you also possess an impressive arsenal of invaluable technical and analytical experience and specialist knowledge, as well as non-cognitive qualities such as the tenacious mentality to deal with repeated setbacks and tackle seemingly insolvable problems.

By reassessing your flourishing skillset you can also start to visualize how an employer might hope to put those qualities to use. And yet for many postdocs, taking the time to sit back and think about this can be challenging. In the fast-paced world of research it is all too easy to become consumed by the relentless pressures of publishing data, so much so that

"An exit from academia feels like a huge and incalculable risk."

"Research provides an exemplary platform for problem-solving"

the pursuit of extracurricular activities can slither down the priority list or disappear altogether. But when the grant ends many postdocs can be left

blinking into the headlights of the oncoming employment gap. By seeing it as an essential part of career progression, time spent improving other areas of your CV begins to climb to a higher priority position.

Non-research-based activities come in all shapes and sizes and rather than being a distraction from research, should instead be viewed as an essential attribute to postdoc life, not simply because they will improve your appeal in the non-academic job market, but also because the institution each postdoc belongs to is built on a vast mechanistic framework, the functioning cogs of which are in prime position for any inquisitive postdocs to access. Delving into these hidden workings can reveal previously unrealized interests or talents – a flair for interdisciplinary communication might be useful for outreach programs or establishing institutional collaborations, for instance; holding positions in various association, regulatory or legislative committees not only provides a fundamental opportunity to network and have a voice in more than your own research project, but also to witness the crucial organization and backbone of the institution. Showing this initiative and learning how things are done are translatable and precious assets in the job market. Mingling with non-research staff in your own establishment can expose potentially interesting job titles that you never even considered.

Other worthwhile ventures can be subtly embedded in postdoctoral life. Contributing to peer-reviewing of pre-publication papers boosts critical thinking and increases awareness of frontline research, but also lends itself to editorial and publication companies, which benefit enormously from the experience retained by postdoctoral researchers. Useful insights into alternative careers can also be found in the form of internships, temporary positions that should not only be considered by pre-graduates, but by anyone wanting to test unfamiliar waters. Doors into obscure fields such as policy work, technology transfer and licensing can be opened via internships, and afford quintessential meeting grounds with prospective employers. Training seminars and corporate workshop days offer similar opportunities, and also supply glimpses of what different jobs involve and which skills are required.

As such a prized commodity, allocating time to career-related activities must be done carefully and wisely. Remaining glued to the research bench during all waking hours is not the most beneficial nor efficient way of furthering a career, particularly if a route out of academia after a postdoctoral appointment is being considered. Nurturing your skill-set should be a continuous task and will allow you to gain a better perspective of your expertise.

Postdoctoral researchers build up a resilient mindset and obtain the ability to rebut defeat and reject the idea of quitting. This in itself is priceless, but when combined with an inquisitive ability to learn and adapt, as opposed to rigidly gathering knowledge and staying put, a postdoctorate will have a more potent influence on whatever they choose to do.

At NC State, the impressive diversity of research disciplines provides an ideal proxy for postdocs from all arenas to enhance not only their academic experience, but also build a lucrative stockpile of skills. So, for researchers who are contemplating work in the outside world, it is not so much about giving up and leaving the academic queue, it is more about realizing the profound impact you can have, acknowledging your strengths and seeking out your next task, no matter where it might be. ■

- Greer Arthur

The Maze



“When the grant ends, many postdocs can be left blinking into the headlights of an oncoming employment gap.”

“Nurturing your skillset will allow you to gain a better perspective of your expertise.”

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DORIS SANDE

President of the Postdoctoral Association



From the PDA PRESIDENT

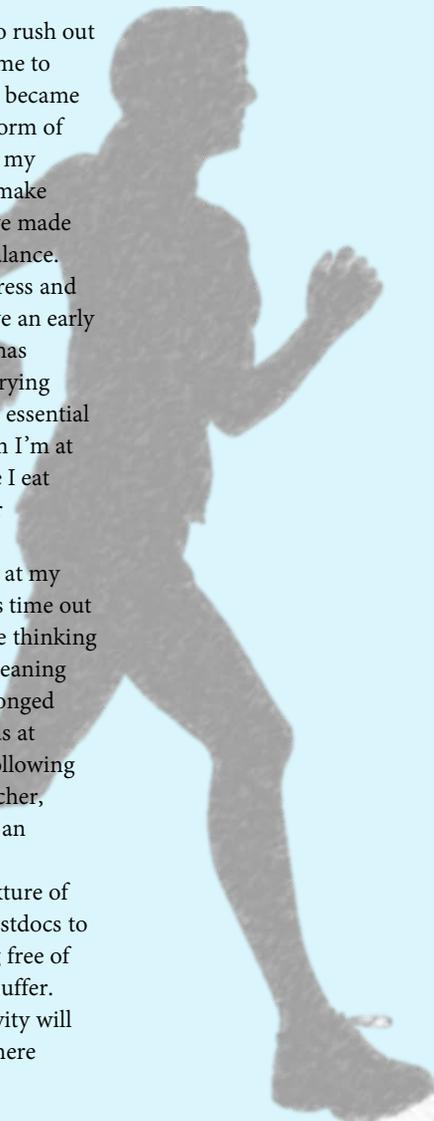
About 15 years ago I moved from Kenya to the United States. I moved to Raleigh in 2010, after completing a Masters and PhD degrees in Agricultural Economics from the University of Georgia. Before starting my current postdoc position in Agricultural and Resource Economics in 2015, I completed a 3-year postdoctoral position on Centennial Campus with the Southern IPM Center as an evaluation specialist. My current research involves work on precision agriculture in cotton; pollinators and crop insurance.

Postdoctoral research is well known to be a difficult job, not just because postdocs can feel confined to their own lab or office, but also because the very nature of the work makes the job too efficient at eating into a postdoc's free time and exhausting their personal life. This is something I have experienced first-hand, like many others.

Over the course of my career, for too long I woke up tired, only to rush out of the house to work a long day, and then eventually drag myself home to sleep. I repeated this cycle day after day, week after week. Weekends became more about recovery from the week than enjoying myself, and any form of exercise was frequently abandoned because I knew I had to set aside my energy stores for work. Exhausted, I eventually realized I needed to make some serious changes. Since reviewing how I manage my time, I have made the decision to reshuffle my work style and improve my life-work balance.

There is still more reorganizing to be done, but I'm making progress and so far I am happy with what I have achieved. My work days now have an early start of 6am – counter-intuitive, perhaps, but in fact this extra time has allowed me to fit in some much-needed “me” time. Rather than hurrying straight to work, I now allow myself 30 to 45 minutes for prayers, an essential part of my day, followed by a 30 minute run or brisk walk. By 8:30am I'm at work and treating myself to a hot cup of Kenyan tea and I make sure I eat breakfast – usually a *mandazi* (a type of Kenyan donut) or a bagel or sandwich.

My research demands a lot of computer work, which forces to be at my desk for most of my day. A recent change I have prescribed myself is time out to walk outside at lunch break, a valuable break that does not involve thinking about work. By the time I return to my desk I feel more refreshed, meaning my afternoons are productive and efficient, rather than being a prolonged battle against tiredness. I make a point of ensuring my work day ends at 5.30pm, at which time I leave and consciously stop my work from following me home – something my husband, who is a plant pathology researcher, encouraged me to do. This can be tricky, mainly because research is an unending pursuit, and the amount of data you generate is directly proportional to the number of working hours. Combined with a mixture of pressure and guilt, this makes research very effective at shackling postdocs to their desks or lab benches. However, I strongly believe that breaking free of this bind and taking some time to reset will not cause your work to suffer. Instead, as well as each work day being more constructive, productivity will remain higher for longer and mental health will improve. I believe there should be life beyond work.



DORIS SANDE

By freeing my weekday evenings and restricting my work to normal working hours, my weekends have also flourished. Rather than trying to recover from tiredness, I am able to prepare our meals at home and keep up with household chores. I also have time for activities with my family. My husband and I have a 20-year old daughter, who is a junior, and a 16-year old son in junior high school, and we value all our time spent together as a family. I carve out time for personal hobbies including gardening (it's going really well – I'm growing tomatoes, black eyed peas, pumpkins, collard greens, and even a pineapple), and I also now participate actively within my Christian community. I find these activities extremely therapeutic, which makes them an essential component of my work-life balance. I believe each day is given to us only once and it is blessed, what we do with it is a choice, so I always try to make the best of and enjoy every second.

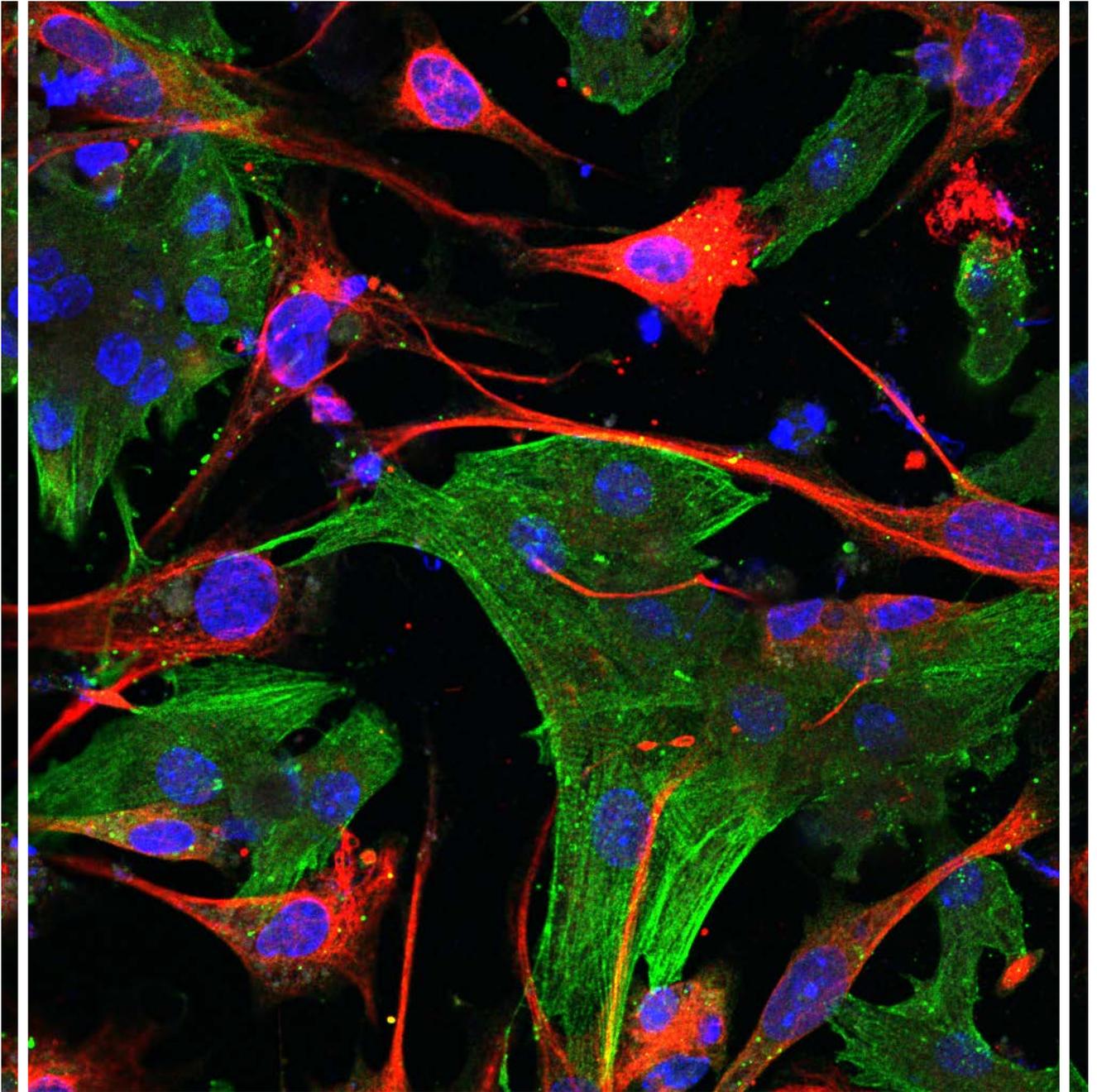
In both my postdoc positions, I have found it to be quite lonely, and more so if you happen to be the only postdoc in the department. Working in this situation has made me understand all too well how easy it is to feel somewhat isolated, and as it turns out, I'm not the only postdoc at NC State who feels this way. We are a relatively small community here, and after talking to some other postdocs, feeling out of place seems to be common to postdocs across several departments. As the new President of the Postdoctoral Association (PDA), I would like to reassure any postdocs who have experienced this loneliness and isolation that there is a postdoc community on campus, and although it's small, it definitely exists, and I urge you to get involved. PDA meetings are held every month and are a perfect opportunity for you to meet others postdocs like you and get involved with the bigger picture. The time has come to combat this postdoc segregation by improving our communication at NC State, to help all postdocs realize that they belong here and play a significant role at this University. We are our voice, so let us join together to make our PDA heard.

Although postdoctoral positions are a chance for us to receive training and mentoring, much of what we learn is self-guided, including learning the work-life balance. This is because the process through academia is neither linear nor clearly defined. One of the ways I intend to provide support to NC State postdocs as the PDA President is to invite guest speakers to discuss different career paths and training, as well as ways of navigating through postdoctoral life and an academic career. I especially hope to make contact with Assistant Professors who already display exemplified productivity in their fields, because not only have they already successfully survived their time as a postdoc, they are also still weaving their way through their own set of obstacles.

Finally, I also plan to work with NC State to enhance and tailor the introductory orientation meetings for new postdocs. While the orientation meetings are useful, I feel additional information about the existing postdoctoral community as well as who the PDA and the Office of Postdoctoral Affairs (OPA) are is needed. This is the one crucial avenue for new postdocs to know about the PDA. I hope to improve the attendance at postdoctoral meetings and together we can improve the postdoc experience at NC State. So if you can spare a little time to join us, even if it is for a one-off occasion, I would love to meet you. ■

- Doris Sande





Efrain Rivera-Serrano

Photographing the invisible



Efrain Rivera-Serrano is a PhD student in the Department of Molecular Biomedical Sciences at NC State University, funded by the National Institutes of Health. He received his undergraduate degree from the Pontifical Catholic University of Puerto Rico and his Master's degree from NC State University.

Rivera-Serrano's published work can be found in PLOS One and the Journal of Virology. His current research focuses on exploring the molecular mechanisms of viral infection of heart cells to identify new targets for future medications to combat heart infection.



The cell is a remarkable biological structure that serves as the basis of life as we know it. In eukaryotes, which are mostly (but not exclusively) multicellular organisms such as animals, plants and fungi, the intracellular compartments of the cell are highly organized – akin to a factory and its multiple departments and offices. Importantly, not all 'cells' are the same; and they can vary drastically in their form, arrangement, morphology, movement, mitotic (cell division) rate, and even the abundance of specific organelles depending on the tissue they reside in and their specific functions. The development of fluorescence microscopy in the 20th century opened an inexhaustible number of doors for how biologists study the fundamentals of cell biology, and provided an extremely useful tool for the visualization of what is happening inside the cell under certain conditions.

In my research, I use fluorescence microscopy to address an overall biological question, how do different cardiac (heart) cells respond to a viral infection? A variety of viruses can infect the heart to cause a disease collectively known as myocarditis. In the disease, the virus attacks the heart muscle, leading to inflammation of the heart tissue and disruption of the electrical impulses that set the rhythm of the heartbeat. As

well as weakening the heart, this can also cause heartbeat irregularities and in worst cases, heart failure.

Visualizing whether a virus is inside a cell has been made possible by fluorescence microscopy. Not only does this technique allow me to see the internal structures of each cell type, fluorescence microscopy also allows me to conceptualize the battleground that takes place inside a cell after a virus has entered. One of the main reasons viruses are so efficient at infecting and spreading throughout the body is because they are able to take control of the infected cell's own machinery and replicate themselves to make hundreds and thousands of virus copies. To study this, I am also using fluorescence microscopy to see exactly what happens when this invasion and takeover occurs. A greater understanding these processes will ultimately lead to the design of medication that can help protect and treat myocarditis.

Throughout the evolution of biological research, microscopy continues to function as a fundamental tool for scientists of many different fields, and the constant advancements in microscopy sciences has allowed the progress of research in ways that were unimaginable half a century ago. ■

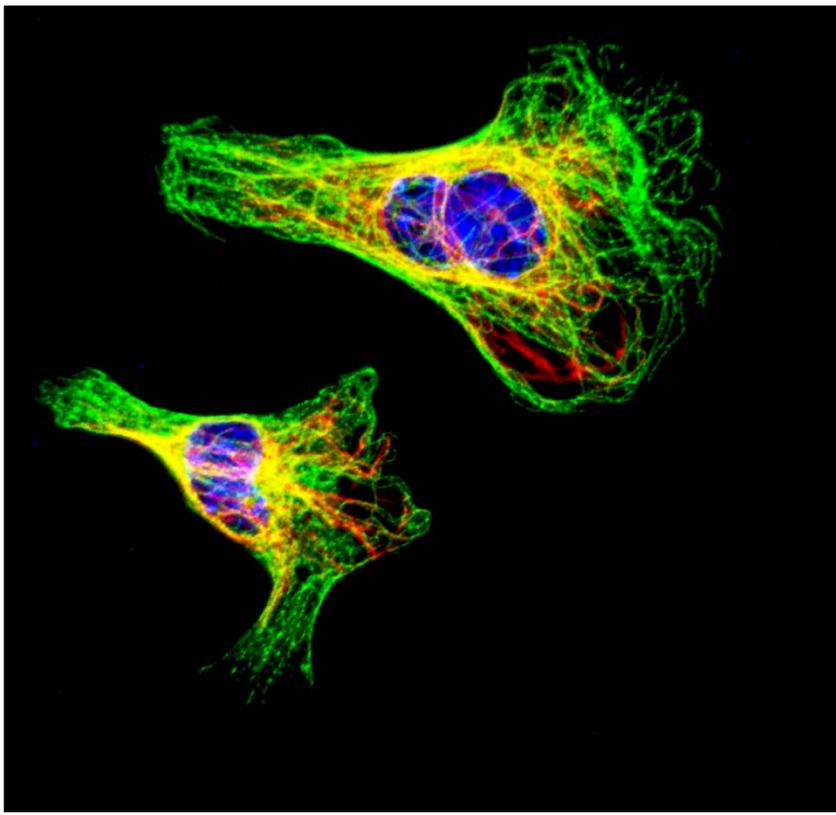
- Efrain Rivera-Serrano

Previous page: The building blocks of a heart

The mammalian heart is chiefly composed of two specific cell types, both of which are essential for proper organ function. Cardiac myocytes, shown here in green, constitute the muscle portion of the heart and execute the organ's 'beating' functions, which are necessary for the distribution of oxygenated blood throughout the body. These cells are largely non-replenishable, meaning that right now your heart will contain pretty much the same cardiac myocytes that you were born with. In contrast, cardiac fibroblasts, shown here in red, are readily replenishable. Unlike myocytes, cardiac fibroblasts ensure the heart functions properly and physiological homeostasis is maintained by secreting a wide variety of soluble signals and proteins.

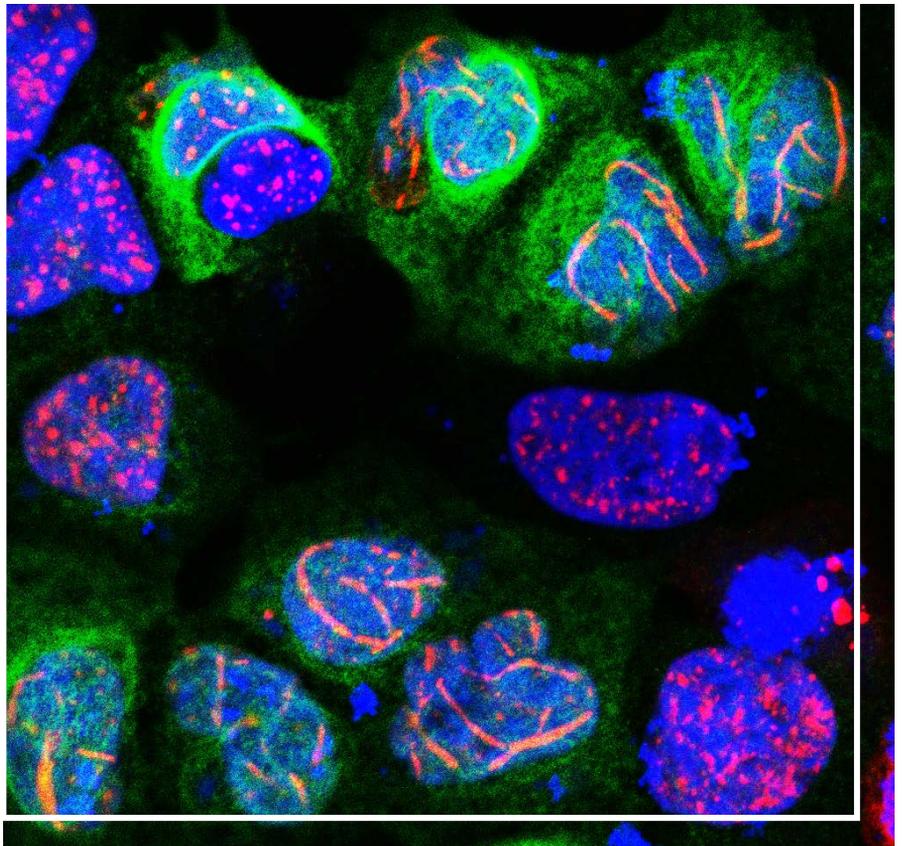
From a mouse heart

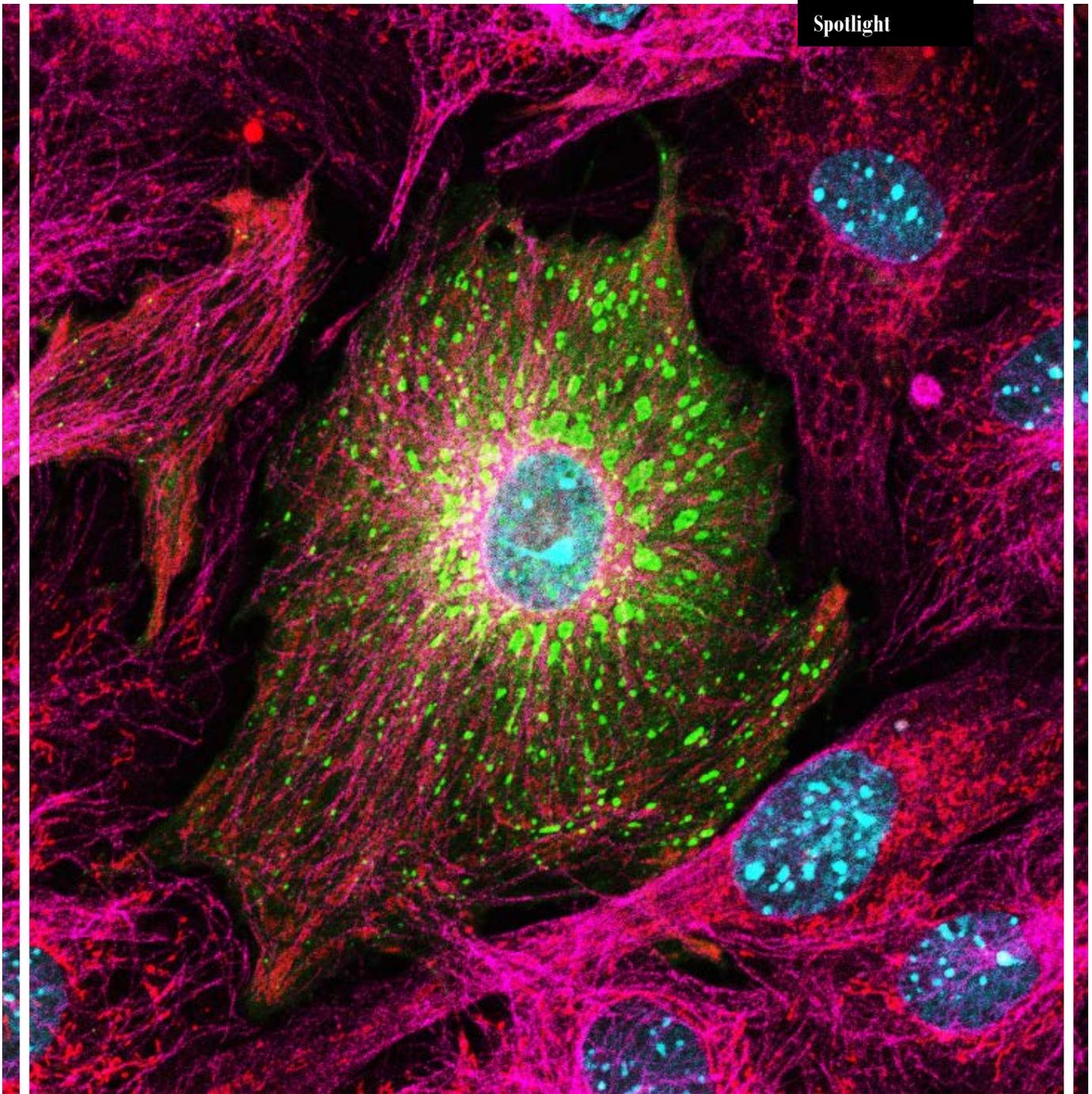
Two individual fibroblasts isolated from a mouse heart. The cell cytoskeleton is responsible for a myriad of cellular processes including maintaining cellular structure, facilitating cell movement, transporting molecules across the surrounding cell membrane, controlling cell division, and many other key aspects. In these two cells, both the microtubule network (green) and intermediate filaments (yellow/red) can be observed; in some cases originating from places near the nucleus (blue).



Viral infection

A culture of mammalian cells, some of which are expressing a viral protein (green). Eukaryotic cells, which are complex and have distinct internal compartments, possess discrete structures (red) inside the nucleus (blue), the control center of the cell. In this image, it is possible to see that the presence of a virus (green cells) has caused the structures in the nucleus (red) to become more filament-like and stringy.





The spread of a virus

The heart is responsible for receiving and distributing blood throughout the animal body. By doing so the heart provides a vital supply of oxygen and nutrients to tissues and organs. Exposed to vast volumes of blood, cardiac cells are extremely vulnerable to harmful blood-borne pathogens, and any microscopic threat, such as a virus, that gains access to the heart therefore has the potential to cause damage to the heart's tissue. In this image, a culture of cardiac

fibroblasts have been infected with a virus to study how the infection took place. The cytoskeletal framework of the cell (magenta), the cell's energy-generating mitochondria (red), and the central control system of the cell, the nuclei (blue), of each cardiac fibroblast can be seen. The cell in the center has been infected with a virus, and clearly visible are the inclusion bodies of the virus (green), which are the sites of viral replication. ■

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