

GW RESEARCH

THE GEORGE WASHINGTON UNIVERSITY
SPRING 2018



FROM THE VICE PRESIDENT FOR RESEARCH



Last year, three students came to my office; all three were sophomores, ambitious young women, and they told me they'd like to launch a comprehensive, peer-reviewed journal of undergraduate research at the university.

And I was taken aback—by their gusto and by their confidence. But also that this idea's time had come at last. It was an exquisite thing to hear after nearly 10 years of work by my office and others to raise

the awareness of research on campus, to raise its reputation *off* campus, and to build a culture where students line up to fortify their education with research—whether that's getting their hands dirty in the field or the lab, writing code or writing prose and excavating knowledge and truth, wherever they find it, for the public good.

It was one of the most heartwarming meetings of my tenure at GW. And the publication of their journal this April—on their own, with only financial support from my office—is as fitting of an exclamation point on my time in this office as I could ask for. I've decided to step down from my post this summer to rejoin the academe as a professor of pharmacology and physiology in the GW School of Medicine and Health Sciences.

When I arrived in 2009, the Office of the Vice President for Research had only just been created. And in the years since, the university has leaped nearly three dozen spots—from No. 114 in 2010 to No. 81 in 2016—in the most recent National Science Foundation ranking of expenditures.

We created a clutch of high-profile, university-wide institutes to bring a new interdisciplinary focus to topics like autism, computational biology and the plight of women globally. Among other programs and initiatives, we launched an office dedicated to fostering a spirit of entrepreneurship, and another for incubating corporate partnerships; we injected hundreds of thousands of dollars in seed money into faculty and student research projects; and we started an annual showcase of undergraduate student research, which this year notched a record of more than 650 poster presentations.

Now we add to all of that a trio of journal founders who are moved not only to participate in research, but also to see beyond their fields and to put the findings of others into ink. It's an apt embodiment of the distance we've traveled as a university.

When I first wrote in these pages, in 2011, I shared a favorite lyric, and today—for those students, for GW, for me—it rings as true as ever: The best is yet to come.

Sincerely,

Leo M. Chalupa
Vice President for Research

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Front cover: The whitened wing of a monarch butterfly, resulting from a gene-editing study. (Arnaud Martin/Darli Massardo)

Back cover: A naturally occurring monarch wing. (Arnaud Martin/Darli Massardo)

LOGAN WERLINGER

GENETICS

THE BUTTERFLY'S PAINTBRUSH

Using gene-editing technology, researchers unravel a single gene's varied role across seven species.

// By Kristen Mitchell

There are more than 20,000 distinct species of butterflies in the world today, all distinguishable by the colors and patterns on their wings. Unlocking the causes behind those differences could be a key to understanding biodiversity, says Arnaud Martin, an assistant professor of biology, and a new study of his brings science one step closer.

In his Science and Engineering Hall lab, Martin is using gene editing to study the patterns on butterfly wings. With CRISPR—a technology that can cut DNA at any site in the genome—Martin is able to excise single butterfly genes one by one to determine their function in making shapes and forming colors.

“We know why butterflies have beautiful colored patterns: It’s usually for sexual selection, for finding a mate, or it’s some kind of adaptation to protect themselves from predators,” he says. “What is more mysterious is: How do they do it? How do you make stripes and dots? How do you make complexity?”

Martin’s work focuses on butterfly diversity, but this branch of genetic research has implications for the study of all types of organisms, he says, including humans.

“Our research is very fundamental, and it’s about trying to understand where we come from and how,” he says. “In a way, a butterfly wing is just a pattern with boundaries and specialized cells, and we have that in our own anatomy. If you look at the brain ... to make very complicated brains,



Natural (left) and altered (right) examples of three species of butterflies from the study

you’ve got to make patterns. We don’t know how all these patterns are evolving really well, that’s where butterflies come in.”

In a study published in September 2017 in the *Proceedings of the National Academy of Sciences*, Martin looked at how *WntA*, identified as a hotspot gene for determining wing shape, could evolve to shape different features across species.

Martin and an international team had identified *WntA* as a “painting gene” several years ago in one species of butterfly. Researchers believed the gene was important for laying out the basic pattern

organization of the wing and, for the new study, decided to test the idea by removing the gene in seven butterfly species.

The results have been fascinating, Martin says. The wing patterns changed in significant ways, with colors and trademark patterns altered.

“In every single butterfly, the mutants displayed a variety of modifications in distinct regions of the wing,” Martin says. “Together they make sense, and they tell us something important about genes and evolution. They tell us that a single gene can evolve over and over again to make novelty.”

The research process has been full of surprises, Martin says. CRISPR technology has opened the door for discoveries that would have been impossible just a few years ago.

“Every single experiment has yielded unexpected results, and it’s quite a eureka moment to have a new butterfly coming out of its cocoon and revealing the surprising effects of CRISPR,” he says. “The mutations have had very specific effects. Part of what we got was expected, but not necessarily.”

In the future, Martin hopes to use CRISPR for a more surgical version of genetic modification, in which scientists can cut and insert DNA. This process would allow the researcher to add patterns to the wing and change its size in a controlled way to test hypotheses about the genetic mechanisms that create shapes.

“I think the work we’re doing right now is kind of opening a window on new opportunities to study biodiversity and hopefully bring attention to the hidden secrets of these creatures,” Martin says. “There is a lot of value trying to explain the complexity and the beauty of the universe around us, especially living things. It’s an infinite template of wonder.” BWR

A BUDDING LABORATORY

Eight stories above the bustle of Foggy Bottom, the new Wilbur V. Harlan Greenhouse is in bloom. The 1,225-square-foot lab atop Science and Engineering Hall, which opened early last year, is home to nearly 100 different plants connected to research across GW, from studies of marsh plant survival in a rising Chesapeake Bay to the possible reintroduction of the American chestnut tree, which was largely wiped out by a blight in the 1990s. For biology professor Amy Zanne, the greenhouse is also a way to engage students who aren't necessarily planning a future in botany, like many of those in her evolution-centered "Comparative Plant Structure and Function" course. "I try to show them how plants are relevant to their everyday lives and why they should be interested," she says. "I try to get them out here touching, seeing, smelling and tasting them so they can experience these evolutionary steps firsthand." —Kristen Mitchell





HEALTH

HELPING NEWBORNS BREATHE

Doctors have less than 30 seconds to intervene when a newborn is having trouble breathing. They must quickly place a tube through a baby's mouth and into the windpipe—a common procedure, but one that medical students aren't adequately trained to do during residency, according to one group of researchers.

The issue, they say, is the baby itself—that it's not a rubber mannequin, devoid of saliva and tissue and movement, which is what the students are used to practicing on. To get around that, a team of GW researchers, in partnership with Children's National Health System, are building a virtual reality training program, which last year was awarded a five-year, \$1.6 million grant from the National Institutes of Health.

Lead researcher James Hahn, a computer science professor, says that medical residents, after three years of training, currently have just a 1-in-4 chance of correctly doing the procedure, called neonatal endotracheal intubation.

"Usually in an emergency situation there is something obstructing the airway, and you have to quickly get this tube inside the trachea so they can breathe," Hahn says. "You can imagine this would be relatively difficult [on] an adult. But for a tiny baby, the physiology is

obviously different. They are very small, very delicate, and they don't have a lot of breathing reserve, making the procedure very difficult."

Even experts at performing the procedure on real babies don't do significantly better on mannequins than the novices do, Hahn says.

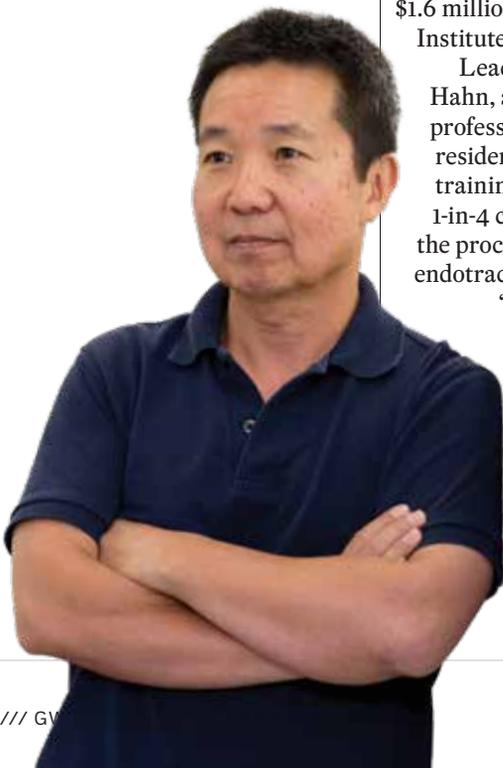
"There is something going wrong here. The training process is not doing what it's supposed to do," he says.

In preliminary work for the project, the team created an augmented reality simulator based on CT scans of an infant mannequin, which were then aligned with the real mannequin using electromagnetic motion tracking. Students performed the procedure and could watch their movements tracked on a computer screen in real time. With recorded 3D examples of both expert and novice users, a machine-learning algorithm was developed to assess performance.

Hahn and his team—Lamia Soghier, a neonatal physician at Children's and an assistant professor of pediatrics at GW; psychology professor John Philbeck; and Naji Younes, an associate professor in the Department of Epidemiology and Biostatistics—plan to extend the augmented reality simulation to a full virtual reality system that does not require the mannequin. Students would use a haptic device to navigate the on-screen procedure, which would provide resistance when the device used to insert the tube presses against the tongue and other parts of the anatomy.

"We could make this as realistic as we want to. Instead of scanning the mannequin, we would use MR scans of real babies to create virtual models. We could then simulate the physics of deformation of the tissue in the virtual model during the procedure," Hahn says.

—Kristen Mitchell



WORLD

CONFLICT ADDS TO PLIGHT OF WOMEN IN SOUTH SUDAN

In South Sudan, armed conflict and displacement intensify violence against women and girls, according to new research by the GW Global Women's Institute.

As many as 65 percent of women interviewed in some locations reported experiencing sexual or physical violence in their lifetime by an intimate partner or non-partner. That rate is double the global average and among the highest levels of violence against women and girls in the world.

The study, conducted across five sites in South Sudan in partnership with the International Rescue Committee, included interviews with more than 2,200 women.

South Sudan declared independence from Sudan in 2011 after decades of civil war, though conflict has continued to erupt.

Women reported increased frequency of assaults by partners in times of conflict, due to the instability of displacement and the economic insecurity it causes. Sexual violence by a non-partner also was exacerbated, according to the study, with many incidents related to a raid, displacement or abduction.

Abuse within the home by husbands or partners was the most common form of violence reported. More than half of the women who ever had an intimate partner reported domestic violence, whether physical or sexual. In the

rural town of Rumbek, 73 percent of women said they had experienced intimate partner violence.

Negative attitudes toward gender equality were found in each study site, and the researchers say long-standing practices, such as forced marriage, have made the violence common. Often violence is committed with impunity, the researchers say, and a culture of shame, around rape in particular, is so severe that many women fear reporting an attack could lead to further repercussions. *GWR*

TECH

THE WEIGHT OF WORDS

Free smartphone app is geared toward helping Hispanic parents boost language development among infants and toddlers.

By the time children from low-income families turn 4, their language skills lag behind their more affluent peers in ways that could impact them for the rest of their lives. It's known as the "word gap," and a nursing professor's new smartphone app is aiming to help Hispanic families, in particular, bridge the divide.

The free app, Háblame Bebé, launched in March and shepherds adult users through developmental milestones starting at birth to age 3.

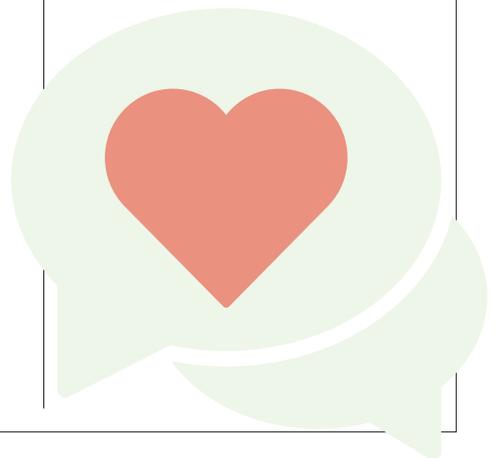
Ashley Darcy-Mahoney, an assistant professor in the School of Nursing who helped develop the app, says the goal is to increase both "quantity and quality of words spoken to

children," since language skills at that age can be predictive of those skills at ages 9 or 10.

Last year, she and her collaborators won more than \$110,000 through the federal Health Resources and Services Administration's "Word Gap Challenge" to build Háblame Bebé. Darcy-Mahoney, the director of infant research at the GW Autism and Neurodevelopmental Disorders Institute and a neonatal nurse practitioner, also had previously worked on the development of a similar English-language program called Talk With Me Baby.

Studies have shown that by age 4, children from low-income families have heard 30 million fewer words than their more privileged peers. Early exposure to words and the quality of verbal interactions can influence how children develop language skills, their performance in school and, later, their economic success, according to the HRSA.

Parents who use the app are able to input their child's age and get reminders about topics they could discuss with their children as their cognition matures. They can input words their child is using, watch short videos that demonstrate ways to interact through singing and other strategies, and they can record videos in the app and share them directly to their social media feeds. —*K.M.*



PALEONTOLOGY

2 MORE DINOS TRADED TEETH FOR BEAKS MID-LIFE

In 2016, a team of researchers reported a series of dinosaur skeletons that showed one species' radical transition from sharp-toothed babies to beaked, toothless adults. Now some of the same researchers are saying the phenomenon may be more common than they'd thought.

In a study published in September 2017 in the *Proceedings of the National Academy of Sciences*, GW

doctoral student Josef Stiegler and his co-authors reported finding two

more dinosaur species that had teeth as a juvenile and lost them as an adult.

Stiegler and the team, led by Shuo Wang at Capital Normal University in Beijing, looked at *Sapeornis*, a bird that lived 120 million years ago. They found individuals in the fossil record with jaw morphologies similar to the ones that researchers—including Stiegler's graduate adviser James Clark, the Ronald Weintraub Professor of Biology—identified in 2016 as *Limusaurus inextricabilis*, part of the group of dinosaurs that are the evolutionary ancestors of

birds. Stiegler and the team also noted comparable jaw morphologies in a small species of caenagnathid oviraptorosaur, a *Velociraptor*-like species but with a toothless beak.

"People have been studying the evolution of beaks for a long time, and studying the loss of teeth for a long time, but it has never been quite clear the interplay between those two phenomena," Stiegler says. "There seems to be something going on where the beak prevents the teeth from growing or the loss of teeth allows the beak to grow."

—Kristen Mitchell

HEALTH

CHARACTERIZING DC'S HIV EPIDEMIC

A new analysis of the evolutionary history of HIV in Washington, D.C., is giving researchers a more comprehensive picture of the epidemic, including clues that might be used to provide better care and prevent new cases.

"The study helps give us a better idea about the genetic diversity and subtypes of HIV in the District," says lead author Marcos Pérez-Losada, an assistant professor in the Milken Institute School of Public Health's Computational Biology Institute. But, he says, more research is needed to probe drug-resistant mutations of HIV found in the study.

D.C. has one of the highest rates of HIV infection in the country, with a prevalence rate of about 2 percent. Yet, few HIV sequences from the nation's capital are available in databases to assess its evolutionary



history, which can help identify factors that contribute to the epidemic.

For the study, published in September 2017 in the journal *PLOS ONE*, Pérez-Losada and his colleagues tried to plug that gap. They analyzed 3,400 HIV sequences, as well as clinical and behavioral data, from nearly 1,900 participants in the D.C. Cohort—a federally funded, long-range study of people with HIV receiving care at 13 clinics in the city—from 2011 to 2015.

The team found that more than 90 percent of the available HIV sequences collected were subtype B—a finding that suggests the city’s HIV epidemic is consistent with that of the broader country, where subtype B is also the most common type, the authors say.

The team also found a high prevalence of drug-resistant mutations in the HIV samples, knowledge that could help guide doctors toward drugs that are more likely to be effective, the researchers say. **GWR**

ASTROPHYSICS

GLIMPING A NEVER- BEFORE-SEEN CATAclysm

Four GW astrophysicists were part of a global group of scientists that studied the first confirmed observation of two merging neutron stars, called a kilonova, which occurred 130 million light-years from Earth.

The existence of a kilonova—the explosive collision of the dense, hulking remains of collapsed stars—had been theorized but never definitively witnessed.

A merging of neutron stars was predicted to generate both gravitational waves and electromagnetic radiation at various wavelengths. Researchers also suspected these mergers as the source of mysterious short gamma-ray bursts. The recent observations confirmed those predictions.

“This is a monumental result—the result of the decade,” says GW physics professor Chryssa Kouveliotou, one of the study’s scientists.

In August 2017, two land-based observatories alerted scientists to the gravitational waves, and two satellites detected a short gamma-ray burst—the most powerful, brightest explosion in the universe—coming from the same

area of the sky. In the days after, other observatories detected the light from the gravitational wave event, confirming the kilonova.

Kouveliotou, an expert on gamma-ray bursts, worked with an Italian research group to study the optical and infrared electromagnetic radiation emitted from the merger. Their work, published in October in the journal *Nature*, verified that neutron-star mergers are major cosmic producers of heavy elements such as gold, platinum and lanthanides.

GW physicist Alexander van der Horst and Kouveliotou studied the light emitted by the collision to learn more about how the light is produced; Bethany Cobb Kung was involved with telescope observations of the infrared glow from the kilonova and studying the composition of material it released; and Sylvain Guiriec analyzed data from the gamma-ray burst. **GWR**

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**“This is a
monumental
result—the result
of the decade.”**

STUDENT RESEARCH

POSTERING THE WALLS

Months and years of work were printed on posters and set upon easels by the hundreds in a pair of annual events showcasing the research of students across the university. At the School of Engineering and Applied Science's R&D Showcase and the universitywide Research Days event, the studies ranged from explorations of liquefiable soil to the thermal detection of breast cancer and the value to restaurants of earning a Michelin Star. Here's a look at a few of the projects.

—Kristen Mitchell



FARMING WITH FISH

Junior Eden Smalley and senior Abigail DeMasi developed an aquaponic system for sustainable farming in the greenhouse on the eighth floor of Science and Engineering Hall. The system uses waste from a tank of koi fish to fertilize plants in grow beds, which then clean the water the fish live in—a loop they hope might encourage sustainable backyard or rooftop farming. The pair found leafy plants like lettuce and kale even grew larger than controls planted in fertilizer. Now they want to expand the system to grow root vegetables, like beets.



JOB-SEEKERS WITH AUTISM

Katherine Hurley, a doctoral student studying counseling, is researching the benefits of, opportunities for and barriers to agricultural sector jobs for adults with autism spectrum disorder. Farms and agricultural hubs have started working with adults with ASD, with many of those programs resulting from a family member with ASD finding meaningful work with their family of farmers, and that family opening its door to more individuals. In the ongoing research, Hurley plans to work with

farmers, families and individuals with ASD to develop guidelines for best practices for these types of programs.



MAPPING ASTEROIDS

Doctoral student Shankar Kulumani developed a way to quickly and efficiently discern the exact shape of an asteroid, using lasers to measure the distance from a spacecraft to the surface of an asteroid and creating a 3D model. It would allow for asteroids to be measured on approach, rather than from the ground, guiding efforts to then maneuver around them or make a landing.



AN ONLINE SAFETY NET

A group of students led by junior Samsara Counts designed a screening tool for identifying online content related to eating disorders. The tool would recognize images and hashtags common to online communities that glorify eating disorders and thin bodies, allowing clinicians to see what patients are posting and to keep up with trends online. It also could be used to build a browser extension that filters potentially harmful images that could trigger a backslide.

STUDENT-LED JOURNAL LAUNCHES

A new student-led academic journal debuted this spring, focusing on research by undergraduate students.

The inaugural issue of *The GW Undergraduate Review*, which published in April with support from the Office of the Vice President for Research, spans the social sciences, humanities and STEM fields.

Editor-in-Chief Margaret Steiner, a sophomore majoring in applied mathematics, hatched the idea for the journal with sophomores Aleksandra Dagunts, a biology major, and Delaney Foster, a mechanical engineering major, who serve as the journal's associate editors.

Steiner, a research assistant at GW's Computational Biology Institute, hopes the journal adds buzz to the work of undergrads.

"There's no lack of opportunities to do research at GW, but a lot of people don't know the opportunities are there," she says. "Having a journal, I see it as a way to just make that more visible."

The journal joins two field-specific undergraduate journals published at GW: *The GLOBE*, for international affairs, and *GW Historical Review*, for topics in American and world history, along with journals run by students at GW Law and the School of Medicine and Health Sciences.

"The journal will give students an opportunity to learn new skills while highlighting original research and scholarship conducted by their peers," Vice President for Research Leo Chalupa says of the new journal. "Supporting this project was one of the easiest decisions I have made as vice president for research." —KM

ESSAY

ON RESEARCH

This spring, the Office for the Vice President of Research put out a call for essays on the experiences of students in research. Ten essays—including the one below by senior Alisha Anaya (which was edited for space)—were awarded \$500 prizes.

Over the last three years, I have had the immense privilege of working in the Hominid Paleobiology Lab at GW, part of the Center for the Advanced Study of Human Paleobiology—a mouthful, I know. During my time working as a research assistant, I have learned a lot more than just how to say the department name correctly on my first try.

I am a first-generation college student, and the logistics of navigating university life can be overwhelming. Arriving at GW, I felt inadequate in comparison to other students—that I did not belong and was not prepared. I felt similarly out of place during my first semester in the lab, where I was the only undergraduate research assistant, and I would be for some time. Thankfully, though, this meant that I received a great deal of one-on-one training, encouragement and quizzing from others in the lab. My adviser, Sergio Almécija, was especially patient. Even when I would accidentally delete entire 3D skeletal models (sorry!) or when I would incorrectly label bones (I'm better now, I promise), Dr. Almécija was kind and forgiving. He helped show me that mistakes are part of the learning process, and that the ability to move past them symbolizes true learning.

Once I paid my dues in the lab (e.g., learning how to operate the 3D scanners, editing the 3D models



and perfecting the snack spread for lab meetings), Dr. Almécija suggested that I begin my own research project.

To be completely honest, this shocked me. Though I was beginning to hold my own in the lab, the idea of conducting an entire research project felt impossible. I remember attending my first lab meeting, where I was so nervous that I stuttered over the words “*Australopithecus afarensis*.” Feelings of inadequacy crept back into my mind, but with guidance from Dr. Almécija, and a lot of hard work, I pushed forward. Back then I did not think I was capable of finishing even one project, and yet, here I am, about to walk away with three conference presentations under my belt, and a draft of my first scientific paper on standby.

I have dedicated the last three years to research on bipedal locomotion, the evolution of the arch of the foot and skeletal anatomy. But when people ask me about the lab, I tell them about the people, not the software programs. I tell them about our end-of-year lab meetings and mid-afternoon

breakfasts. I mention the Friday morning Metro rides to the National Museum of Natural History and late-night “study sessions.” I talk about the quality of work that is expected of us and how we have learned to expect it from ourselves.

Working in the lab has opened up to me a whole world of research. This year, I returned to D.C. midway through winter break to intern in the Paleobiology Department at the Smithsonian, a position for which I was qualified thanks to the expertise with 3D imaging programs that I learned in my lab. To feel that I have unique knowledge that can be applied in diverse settings makes me extremely proud.

Growing up, college felt out of reach. I didn't have a computer at home until the 10th grade, but now I train graduate students on 3D data visualization software. Even when my eyes burn from lack of sleep and my neck aches from sitting at the computer, I remember how fortunate I am to be working in this lab, with a group of people who make me feel valuable and capable, and with whom I have learned, made mistakes and grown. GWR



VACCINES

HOOKWORM VACCINE ENTERS PHASE TWO

Vaccine would prevent reinfection by the parasite, which affects some 500 million globally.

Buoyed by a new, \$3 million National Institutes of Health grant, GW researchers are starting the second phase of clinical trials on a potential vaccine for hookworm infection.

“This will be the first proof of

concept, or proof-of-efficacy study that we have done,” says David Diemert, an associate professor of microbiology, immunology and tropical medicine, who is leading the study with Jeffrey Bethony, a professor in the same department. “Everything before has just been looking at immune responses and safety.”

Hookworm is an intestinal parasite that afflicts more than 500 million people worldwide, overwhelmingly in impoverished areas, and causes anemia while hampering cognitive and physical development, making it especially dangerous for children.

The new phase is a so-called challenge study, in which participants are inoculated with the vaccine candidate, then monitored for infection after a gauze pad with hookworm larvae is applied to their arm.

Hookworm is typically

transmitted when a person, usually barefoot, steps in soil contaminated by another person’s infected feces. Hookworm is currently treated with annual anti-worm drugs, which do little to prevent reinfection and may create drug resistance in the future. A vaccine would allow the body to block the parasite before it attacks and improve life for people living in endemic areas like South America, sub-Saharan Africa and Southeast Asia. Hookworm is virtually nonexistent in the United States.

“Current treatment provides temporary relief in terms of curing some infections and reducing the burden of others,” Diemert says. “But since the people are living in a contaminated environment, they quickly get reinfected. That’s why we believe that developing a preventative vaccine would be a much better means of controlling and potentially eliminating this infection.” GWR

ENVIRONMENT

EMISSIONS TEST

GW team advances to the finals of Carbon XPrize competition.

A team of GW researchers in April was named a finalist in the \$20 million NRG COSIA Carbon XPrize competition, aimed at spurring technologies that convert carbon dioxide into products with value.

The team, led by Professor of Chemistry Stuart Licht, is one of 10 teams from five countries advancing to the finals. Licht's group is using low-energy, low-cost technology developed in his lab at GW's Virginia Science and Technology Campus to turn carbon dioxide into hollow nanofibers, called carbon nanotubes. These lighter-weight alternatives to metals are strong and highly conductive, and currently are used in the bodies of airliners like the Boeing Dreamliner, high-end sports cars and nanoelectronics and to store energy in electric vehicle batteries.

Previously, Licht says, there was not a cost-effective method for preventing carbon dioxide emissions, a greenhouse gas, from the burning of fossil fuels or eliminating other CO₂, which is causing global warming.

"We have solved that problem by inexpensively transforming the CO₂ into a valuable product," he says. "The product, carbon nanotubes, worth on the order of a quarter million dollars per ton, should be viewed as valuable materials for companies to consider using in their products. We are already seeing that the market for such carbon composites is increasing similar to where the market for plastics was at

the start of World War II."

Licht's team is called C2CNT, short for carbon dioxide to Carbon NanoTubes. The C2CNT process works by dissolving carbon dioxide into a molten carbonate "bath," the researchers say. An electrical current is run through the liquid, splitting the CO₂ molecules into their constituent parts: carbon, in the form of nanotubes, and oxygen.

To get to the finals, the team had to demonstrate a pilot run of the technology during the 10-month semifinals. The 10 teams split a \$5 million purse for making it this far. In the final round, teams will need to operate at full scale, either at a coal-fired plant in Gillette, Wyo., or—as Licht's team is doing—at a natural-gas-fired power plant in Alberta, Canada.

The final round runs until 2020, and carries two \$7.5 million grand prizes, one for each of the two power-plant tracks. GWR

ENERGY

HARVESTING MORE OF THE SUN

A project awarded \$1.45 million by the U.S. Department of Energy is aimed at producing what could be the world's most efficient solar panel, while also making the technology more competitive cost-wise.

Matthew Lumb, a research scientist at the School of Engineering and Applied

Science, is leading the effort. He works with micro-scale solar cells, the size of a period printed at the end of a sentence, which last year he and a research team reported they had stacked together to form a single device capable of capturing nearly all of the energy in the solar spectrum.

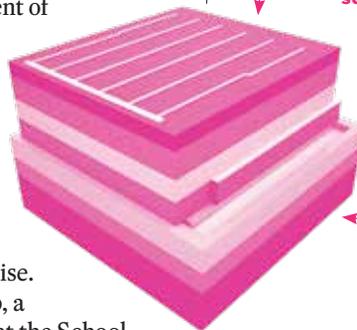
The combined concentrator photovoltaic, or CPV, panels use lenses to stream sunlight onto the cells, magnifying the sunlight by more than 500 times. And the stacked cell acts almost like a sieve for the light, with the specialized materials in each layer absorbing the energy of a specific set of wavelengths.

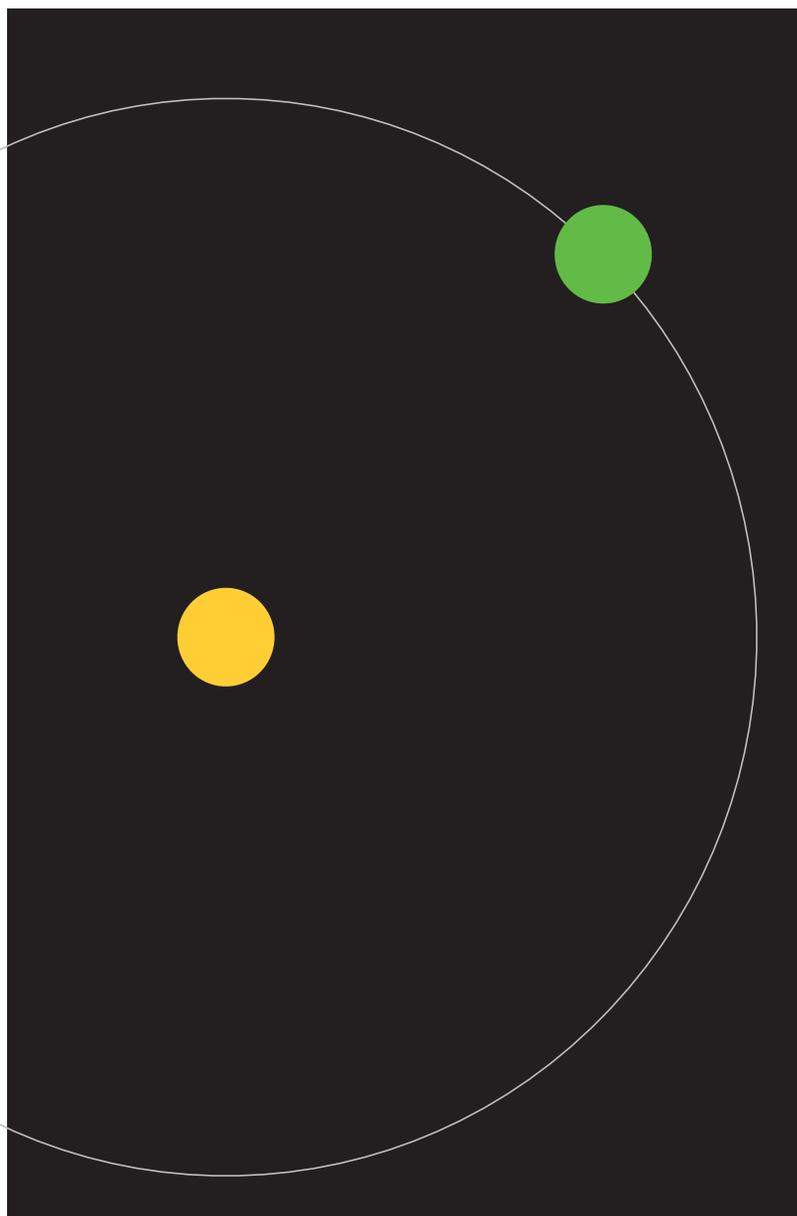
The concentrated light, Lumb says, reduces the amount of expensive solar cell material required and replaces it with much cheaper materials, like glass.

The cells are more efficient than the big, grid-like rectangles commonly seen on rooftops, though those are made of more-cost-effective silicon. And while CPV panels need direct sunlight to function—making them best-suited for very sunny, desert-like environments—Lumb's new panel combines CPV with the more common silicon panels to harness both direct and diffuse sunlight. GWR

This tier is a conventional multi-junction solar cell, absorbing shorter-wave solar photons.

Using materials found in applications for infrared devices, this tier absorbs longer-wave solar photons, helping the cell to capture 99 percent of the solar spectrum reaching Earth's surface.





PHYSICS

'TO CALL THIS A GIANT FUSS IS AN UNDERSTATEMENT'

Answering a riddle at the heart of the atom may portend a new model of physics. // By John DiConsiglio

The tiny world of the proton is on the cusp of big news, anticipating the answer to a mystery that's divided the scientific community and threatened to upend everything we know about physics.

"To call it a giant fuss is an understatement," says Evangeline J. Downie, an associate professor of physics.

The proton, the plentiful particle that makes up much of the visible matter in the universe, may be smaller than scientists have long believed—specifically, 4 percent smaller, or about a trillionth the width of a poppy seed. And that infinitesimally tiny degree has sent scientists "running in circles," Downie says.

"The proton makes up about 50 percent of all observable matter, and we aren't sure how large it is," says Downie, who's also an associate dean at the Columbian College of Arts and Sciences. "That's huge."

Backed by funding from the National Science Foundation, Downie and an international team of 45 scientists, including GW physics professors William J. Briscoe and Andrei Afanasev, are attempting to crack what's become known as the "Proton Radius Puzzle." Begun in 2012, their groundbreaking experiments now are heading into the home stretch—and their results may herald a fundamental new theory of physics.

INSIDE THE PROTON

Protons, the positively charged particles in the nucleus of every atom, are a cornerstone of centuries of science. They formed just millionths of a second after the Big Bang. Protons generate heat in the core of the sun, whiz through space as cosmic rays and are fundamental components of virtually all of the

matter around us. Even small shifts in our understanding of them could have large-scale implications.

Protons are too small to be measured directly. Instead, scientists devised two methods for determining the particle's radius. One is electron scattering: firing a beam of negatively charged electrons at a hydrogen atom and measuring the scattering angle as the electrons deflect off the nucleus' lone proton. The second involves jolting an electron with energy to kick the particle between orbits within the hydrogen atom. By measuring the exact frequency of the laser that propels the electron between orbits, scientists can determine their energy difference and estimate the proton's size.

Historically, both methods had yielded results that agreed with each other: a proton radius of 0.88 femtometers. "And as long as the two methods agreed, everybody was happy," Downie says.

But in 2010, scientists working at the Paul Scherer Institute in Villigen, Switzerland, accidentally flipped the world of physics on its head. Attempting merely to improve the precision of the known proton radius, they tried a novel twist on the laser-transition method. The group replaced the electron in a hydrogen atom with a muon, a particle identical to an electron but about 200 times more massive. The experiment should have provided a more precise measurement without fundamentally changing the equation.

Instead, Downie laughs, "they messed everything up."

The muonic radius disagreed with both electronic measurements, recording 0.84 femtometers instead of the standard 0.88. The discrepancy was tiny—a femtometer is a millionth of a billionth of a meter—but it was significant enough to confound

physicists. Experimental error became less likely as the results were scrutinized and confirmed by other methods.

The mystery runs so deep that some scientists have contemplated a once unthinkable violation of a sacred principle of physics: Could there be an unknown new particle that interacts with muons but not electrons? That scenario would be revolutionary, Downie explains. If true, "it opens a whole new world of understanding."

THE MUSE MISSION

The muon mystery led to the formation of the international research team and a project they called the MUon proton Scattering Experiment (or MUSE) collaboration. The group plans to perform a definitive experiment: a version of electron scattering with muons. If the muon scattering numbers agree with the smaller radius, there will be little doubt that the new proton size is correct for muons—and that could lead to a rethinking of traditional physics.

But preparing for the muon scattering experiment has been a massive undertaking. In 2012, MUSE received a \$900,000 grant from the National Science Foundation simply to design and build equipment. With construction nearly complete, Downie, who is the lead spokesperson for the MUSE Collaboration and its head investigator at GW, is leading the second phase of the project. She recently secured a \$420,000 NSF grant to finally run the

experiment.

Beginning next year, the MUSE Collaboration will conduct two separate six-month muon scattering operations at the Scherer Institute in Switzerland. Downie, Briscoe and Afanasev—along with a team of CCAS postdoctoral, graduate and undergraduate students—are in charge of the data acquisition system that will capture and process the muon scattering angles from more than 3,500 detector elements.

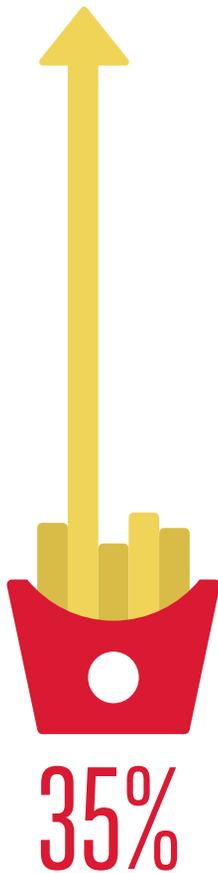
The MUSE team may not reach a final verdict until 2021. And while Downie says she's officially neutral about their prospective findings, she admits that the idea of taking science where it's never gone before is a physicist's dream.

"We could be pushing the edge of what's thought to have been possible," Downie says. "We could be going beyond all of our boundaries." GWR

.84 FEMTOMETERS

The controversial revised estimate for the radius of a proton, which is smaller—by about a trillionth the width of a poppy seed—than the prevailing wisdom. GW physicists are preparing to definitively test that number.





The increase, approximately, in evidence of chemicals called phthalates found in people who said they ate more restaurant, fast food and cafeteria meals over a 24-hour period than those who ate home-cooked meals, according to a new study by Milken Institute School of Public Health Assistant Professor Ami Zota. The hormone-disrupting chemicals, which Zota says are linked to fertility problems and pregnancy complications, are found in take-out boxes and other food production items. Past research suggests the chemicals can leach into food from plastic containers or wrapping.

The age, roughly, of pigments and more sophisticated stone tools uncovered in southern Kenya, pushing back the material record for such objects by tens of thousands of years, to around the emergence of *Homo sapiens*, and suggesting the existence of social networks. Anthropology Professor Alison Brooks was the lead author on one of three papers from the international team published in March 2018 in the journal *Science*.

320,000



“The combination of eroding expertise and political polarization are a lethal combination, no pun intended.”

—Janne Nolan, a research professor at the Elliott School of International Affairs, and chair of the influential, nonpartisan Nuclear Security Working Group, which was awarded \$3.5 million from the John D. and Catherine T. MacArthur Foundation to expand a pilot program that encourages informed consensus in Congress on nuclear issues. The fellowship program, which places experts in congressional offices for a one-year term to help ease staffing shortages, this year increased to seven fellows, up from two in its inaugural year.



64



The number of Americans who have traveled to join jihadist groups in Iraq and Syria since 2011, according to new research from the Program on Extremism. At least 50 others from the U.S. attempted travel, but were stopped by law enforcement. Of the 64—which one of the researchers says is “relatively small” compared to other Western nations—12 have returned to the U.S.; nine of them have been arrested and charged with terrorism-related offenses, according to the researchers.

IN BRIEF

MINING GLYCANS

The National Institutes of Health has awarded a \$10 million grant to scientists at GW and the University of Georgia to build an informatics portal for glycoscience, the study of the structure and function of carbohydrates. Work on the portal, called GlyGen, is led at GW by Associate Professor of Biochemistry and Molecular Medicine Raja Mazumder. The portal will integrate data on glycans—sugar chains made in the body—with gene and protein data and take a big-data approach to revealing larger patterns and trends in glycobiology research.

CULTURAL FAULT LINES

The School of Media and Public Affairs' American Communities Project has been awarded a \$700,000 grant by the Robert Wood Johnson Foundation to expand its work mapping and analyzing the social, political and cultural fault lines that shape the U.S. The grant will enable researchers to mine data sets on health, economics, media consumption and culture. The researchers aim to offer insights into how communities experience their worlds within the nation's political and cultural media bubbles.

ADVANCING COLD PLASMA FOR CANCER

The university last year announced the signing of a \$5.3 million corporate research sponsorship—the largest in GW history—to further work exploring the use of cold plasma as a treatment for cancer. The funding from US Patent Innovations LLC expands a collaboration between Michael Keidar, a professor in the Department of Mechanical and Aerospace Engineering, and surgeon Jerome Canady, the chief science officer of the Jerome Canady Research Institute for Advanced Biological and Technological Services, and chairman of the USPI board of managers.

AUDITING HURRICANE MARIA'S TOLL

Puerto Rico Gov. Ricardo Rosselló Nevares announced in February that a research team from the Milken Institute School of Public Health will conduct a study to estimate the mortality tied to Hurricane Maria, which hit the island in September. Early counts set the death toll at 62, but other reports estimate it to be much higher.

HONORS

Sean D. Murphy, the Manatt/Ahn Professor of International Law, this year became president of the American Society of International Law for a two-year term.

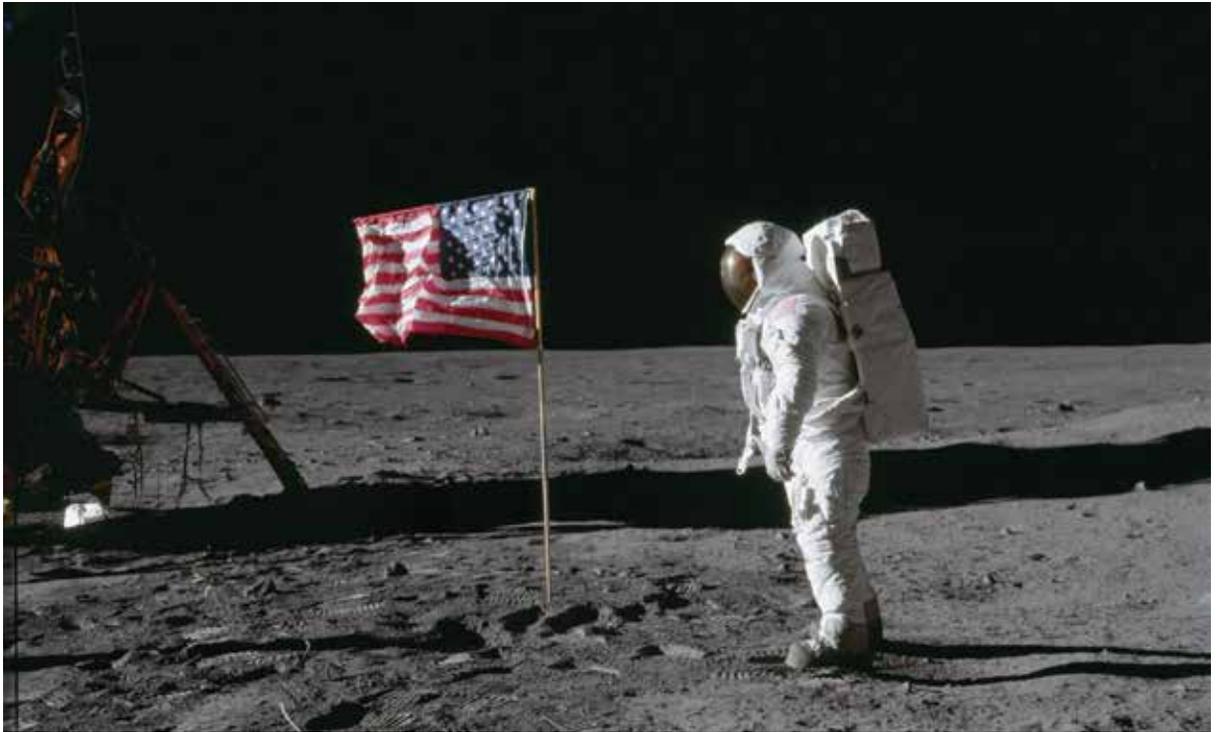
Electrical and Computer Engineering Professor **Mona Zaghoul** has been inducted into the National Academy of Inventors.

Gregory D. Squires, a professor of sociology and of public policy and public administration, was awarded the Urban Affairs Association's 2018 Contribution to the Field of Urban Affairs Award. Squires' work has helped shape debates around discriminatory lending, redlining and the near-collapse of the mortgage market in 2008.

Assistant Professor of Physics **Sylvain Guiriec** was awarded the 2017 Exceptional Scientific Achievement Medal from NASA for his work on gamma-ray bursts and their use as cosmological probes. Guiriec has been an astrophysicist at NASA Goddard Space Flight Center since 2011.

Annamaria Lusardi, the Denit Trust Chair of Economics and Accountancy, was included on Clarivate Analytics' 2017 Highly Cited Researchers list in the economics and business category, placing her among researchers who most frequently published papers over the past decade that have ranked in the top 1 percent of citations.

The IEEE Computer Society named **Tarek El-Ghazawi**, a professor of electrical and computer engineering, to its Distinguished Visitors Program, a three-year appointment in which he'll lecture around the world about high-performance computing, post-Moore's Law processor paradigms and extreme-scale computing.



A RETURN TO THE MOON

The Elliott School's Scott Pace now leads President Trump's revived National Space Council, which has its eye on the moon.

Last summer, **Scott Pace**, on leave as director of GW's Space Policy Institute, was appointed executive secretary of the National Space Council, a White House organization that was re-formed in July 2017 and has existed on and off since the late 1950s, most recently under President George H.W. Bush. (Pace previously served as NASA's associate administrator for program analysis and evaluation.) The NSpC oversees and coordinates U.S. space policy for military, civilian and commercial sectors. We spoke with Pace last fall about the NSpC, the moon and Mars.



▲
Apollo 11 astronaut Buzz Aldrin stands on the moon in July 1969. The Apollo 11 mission landed humans on the moon for the first time.

What are the NSpC's policy priorities?

Doing human space exploration, with a human return to the moon as part of it ... with international and commercial partners. Returning to the moon is not like it was in the 1960s, when it was a Cold War race against the Soviet Union. In this case, it's more about expanding economic and scientific and cooperative opportunities, so going to the moon by ourselves would not be the point. The point is to go in partnership with industry and the larger international community.

What do we want to get out of going back to the moon?

First of all, rebuilding a capability for deep-space exploration that has gone away and lapsed, and we have not only new technologies, but we have a whole new generation of

people.

The second purpose of it is scientific research. There's lots of things to be done still on the moon—and there's things to do on Mars and other planets—but science is part of it.

The third thing is to get other developing space programs, both in the private sector and the international sector, to align themselves more closely with us. The world today is very different than it was in the 1960s—or even at the end of the Cold War when the last Space Council was around. ... You have a much stronger private sector; you have a much more diverse and capable international sector. Those groups can develop separately and independently and may be somewhat in competition with each other, or they can have common projects, and while still competing commercially, can kind of pull in a more common direction.

Is there a timeline to get back to the moon?

It depends on what the budget can afford, and that's a debate we're having now. Certainly, there are a lot of private-sector people who have ideas about how to do it more quickly than conventional government-contracting programs, but also those are potentially higher risk. So I think what you'll see is a mixture of ideas. You'll see things which are more traditional government-contracting, NASA-directed programs, but you'll also see more entrepreneurial and private-sector ones, possibly funded by NASA, but in more unconventional ways. ... It's possible that you could see a return to the moon by the early 2020s. On the other hand, if the commercial ideas don't pay off, then it's going to be later.

Can we expect a permanent lunar settlement in coming decades?

The question is: What kind of settlement? Is it a settlement that is still highly dependent upon Earth? Is it relatively more self-sufficient? And the hardest thing of all, is it economically self-sufficient? I think economically self-sufficient is pretty challenging and probably unlikely—but there are some people who think it's possible.

A more probable outcome is something like Antarctica. We have scientific bases in Antarctica. We have tourists who go to Antarctica. We have scientific research. We don't have commercial activities, but that's largely because it's governed by the Antarctic Treaty, and that is not necessarily a problem with the moon—you can have commercial activities on the moon. But whether or not a settlement is able to be economically self-sufficient as opposed to physically or technically self-sufficient, those are two different things.

There are international treaties prohibiting nations from claiming lunar sovereignty, but could there be problems with the commercialization of the moon?

Let's suppose two different countries or two different companies want the same portion of the [moon's] south pole where there might be trapped water-ice. That would then be subject to direct negotiation, diplomatic arrangements. One can certainly imagine areas of conflict, but they would have to be worked out just as any other international conflict would be. ... I'd argue that many of the most interesting international relations problems today are in the areas that are beyond traditional sovereignty. So we're talking about cyberspace, Antarctica, the high seas ... and space is probably the biggest problem of them all. But that's what makes it interesting, and that's where there's both

opportunity and danger.

Is Mars doable?

Mars is more of a horizon goal. It's something that is extremely challenging and difficult to do, so that as we're doing things nearer term with the moon or in low-Earth orbit or on space stations, we should be thinking about Mars and we should be thinking about what technical demands a Mars mission would require, such as long-term life-support systems, radiation shielding, better propulsion systems, all those sorts of things.

On the other hand, because it is so challenging, there really are not very many countries [or] private-sector entities that can really participate with us. Elon Musk notwithstanding, it's very difficult to imagine very many governments or private-sector entities able to afford to do that right now. In terms of building a capability of going to Mars, I would argue—others may disagree—that the fastest way to get to Mars is to be able to get to the moon. I used to have a math professor who would say you can't do the harder problem until you do the easier problems. It's basically retraining ourselves to go beyond low-Earth orbit again. ... Do that first and keep an eye on Mars as that horizon goal, but go to Mars when you can bring lots of other people with you—not just a single-nation dash, plant a flag and return. That was a perfectly reasonable strategy in a Cold War context where you're looking to demonstrate prestige and technical capability, but the nature of leadership today is very different than it was in the 1960s. Today, leadership is measured in how many people you can get to want to come with you and want to go with you. I thought that the previous administration's focus on Mars was, in many ways, not really helpful ... because it didn't allow enough opportunity for others to participate in it. — *Matthew Stoss*



WORLD

ECHOES OF RWANDA

Twenty years ago, Professor Abdourahman Waberi traveled to Rwanda to try to relate to the world the genocide that occurred there. The resulting book, “Harvest of Skulls,” draws from his encounters with victims and murderers.

By John DiConsiglio



In 1998, Abdourahman Waberi, then a 32-year-old novelist and poet, embarked on a mission to Rwanda with 10 African authors and filmmakers. It was just four years after the genocide in which members of the country’s Hutu ethnic majority unleashed a wave of violence mostly on the Tutsi minority. In roughly 100 days, as many as a million people perished.

Waberi, an assistant professor of French and Francophone literature at GW since 2013, went to Rwanda in part to open the eyes of the international community, but mostly to listen. A native of Djibouti, he felt compelled “to mourn with the Rwandan people, to show them compassion and solidarity,” he says.

But when he sat down to piece through the harrowing notes he’d collected, he was reminded of German philosopher Theodor W. Adorno’s dictum on “the impossibility of writing about Auschwitz.” How do you tell the story of an atrocity, Waberi thought, without trivializing people’s pain?

“Language remains inadequate

in accounting for the world and all its turpitudes; words can never be more than unstable crutches,” he says. “And yet, if we want to hold onto a glimmer of hope in the world, the only miraculous weapons we have at our disposal are these same clumsy supports.”

After another trip to Rwanda in 1999, Waberi was ready to begin his book, *Harvest of Skulls*, a mix of fiction, journalism and poetry that he wrote in 2000 but was released in English for the first time last year. And despite the passage of time, he says, the voices of the people there resonate in his life and his work.

Even before that, Waberi’s writing was interwoven with Africa and Djibouti. He grew up in what he calls a shantytown. Few people in his village were literate and, by age 10, Waberi was paid in candy to draft love letters and job applications. In 1977, when he was

12, Djibouti declared independence from France.

Critical of its current regime, Waberi considers himself an exile from his country, which he hasn’t seen since 2007.

In *Harvest of Skulls*—Waberi’s fifth book to appear in English, with two more on the way this year—he set out to represent a full portrait of the genocide, capturing the stories of the victims alongside the murderers. The encounters, he says, are “lightly fictionalized.”

In one chapter, he describes a widow who named her dog Minuar, after the French name for the United Nations peacekeeping mission that she said “failed to protect us.” The dog “fattened up on human flesh during the genocide,” Waberi writes. In a prison, Waberi spoke to *genocidaires* (“those who commit genocide”) who justified their killings as acts of war.

“We found them to be accusatory and punctilious in the way an American attorney can be,” he says. “They were determined, assured in their position and didn’t sound the slightest bit penitent.”

Though he worries still that his writing didn’t do justice to the emotional gravity of the tragedy, he’s encouraged by the emergence of African novelists like Nigeria’s

Chimamanda Ngozi Adichie (author of *Americanah*) and Chigozie Obioma (*The Fishermen*), and Rwandan writers and artists who have since produced works about that dark era.

“Maybe what I did was only to put down a first layer of ink,” he says, “but that first layer may have given

tools to Rwandans to talk about these events.” GWR



Harvest of Skulls (Indiana University Press, 2017)

1 Some Say the Lark (Alice James Books, 2017)

By Jennifer Chang, assistant professor of English

Careful reading of this poetry collection, a 2018 PEN America literary award finalist, unveils layered imagery and storytelling, and frequent citations from literary history. It can be sobering and reflective. “Even when happiest I think about dying,” reads one line. “Who am I to call myself human?” asks another. Another notes that the best walking “is without reason, formless, scattering the self into thinking.” Elsewhere, the author reflects on the creation of poetry: “What does it even mean to write a poem?/ It means today/ I’m correcting my mistakes./ It means I don’t want to be lonely.”

2 An Unlikely Audience: Al Jazeera’s Struggle in America (Oxford University Press, 2017)

By William Lafi Youmans, assistant professor of media and public affairs

When Al Jazeera launched its English-language channel in the U.S. in 2006, it did so in the face of “open hostility” from the Bush administration, which had been “tarnishing the brand as a virtual

enemy combatant,” Youmans writes. In particular, many were outraged that the channel interviewed Taliban members and other insurgents. And yet, the news service grew in reach and reputation, and in 2013, it bought Current TV, which gave it “a sizable cable and satellite TV distribution footprint.” But then, less than three years later, it shuttered the new channel, after having spent some \$2 billion on it. This book tracks Al Jazeera’s efforts in the U.S. and focuses on the geographical forces that shaped its offices in New York, Washington and San Francisco.

3 Winning the Third World: Sino-American Rivalry During the Cold War (University of North Carolina Press, 2017)

By Gregg A. Brazinsky, associate professor of history and international affairs

Sino-American competition in both Asia and Africa was “intense and enduring” during the Cold War, largely driven by status, according to this book, which notes that recent histories have challenged the view that the U.S. was entirely focused on the Soviet Union during the Cold War to the exclusion of other nations. In fact, “when it came to

crafting policy toward the Third World, Americans sometimes viewed Beijing as an even greater threat than Moscow.” Ironically, both the U.S. and China weakened their statuses in this period due to their competition.

4 Set in Stone: America’s Embrace of the Ten Commandments (Oxford University Press; 2017)

By Jenna Weissman Joselit, Charles E. Smith Professor of Judaic Studies and Professor of History

Rather than focusing on theology, Weissman Joselit offers vignettes that explore how the Ten Commandments shaped—and in turn have been shaped by—America. She sketches a lean toward “more colloquial, less august” representations over the 150 years she covers: from an 1850 dustup over an abstracted version in a New York synagogue, which one person suggested Moses himself would scarcely recognize; to an amateur archaeologist who claimed to find an ancient Decalogue in a Native American burial mound; Cecil B. DeMille’s 1956 film, so grandiose that it inspired excavations of the set in the California desert. GWR





DRAFTED DIVINITY

A MARKED-UP, EARLY VERSION OF A CANONICAL ISLAMIC TEXT GLIMPSES THE EVOLUTIONARY HISTORY OF A RELIGIOUS TRACT KNOWN ONLY IN ITS COMPLETED STATE, BUILT TO WITHSTAND THE CENTURIES.

BY MENACHEM WECKER

S

cholars who wish to pore over the medieval manuscript collection at Istanbul's lavish and sprawling Süleymaniye Mosque have to visit its library in person, if they can find it.

Joel Blecher could not.

"You can't blame me for missing it," says Blecher, a historian of medieval Islam.

The 16th-century mosque itself sticks out like an impeccably manicured thumb from the warrens and bustle of the city. It's "one of the greatest architectural achievements of its time," Blecher says, designed

"to look like a domed Byzantine church squared into a perfect cube in the hopes of offering mosquegoers a glimpse of divine symmetry on Earth."

The library, on the other hand, is tucked away in what seems like the back alley of another back alley. Repositories like this one, he says, often are priced out of locations "that would do real justice to the treasures their shelves hold."

When he did find it, Blecher flashed his passport and soon was in a roughly 450-square-foot room with a dozen tired-looking computers, which had a habit of displaying partially darkened

ROLF BACH

screens at inopportune times.

Still, the arrangement worked in his favor during that summertime visit in 2014. Blecher, now an assistant professor of history at GW, had come to dread the looks on the faces of rare-book librarians after they'd spend half an hour retrieving a manuscript only

for him to open it, check the date and the copyist's name, and hand it back. At the Suleymaniye Mosque library, where the entire collection had been scanned but not pored over by a curator, he could click through dozens of manuscripts in a single sitting.

He'd already worked through some 150 or 200 medieval Arabic manuscripts over two days there when he opened a file that would change the course of his career.

Two things immediately leapt off the scanned page amid some messy handwriting: the year 822 in the Islamic calendar (1419 in the Gregorian count) and the phrase "*min imlā' ... Ibn Hajar*"—"from the dictation of ... Ibn Hajar."

Blecher could not believe his eyes.

A COMMENTATOR OF BIBLICAL PROPORTIONS

Though he died in 1449, Ibn Hajar al-Asqalani remains something of a household name, someone that most Sunni Muslims with a religious education beyond childhood would know of and revere, Blecher says.

More than 500 years after his death, his name and work still are touchstones for Islamic scholars and clerics big and small, ISIS propagandists and the mainstream media, including what Blecher calls a "soap opera" in Egypt based on Ibn Hajar's life and times.

His renown stems from a 13-volume commentary on the



hadith: the collected sayings attributed to the prophet Muhammad and other stories about the way in which Muhammad lived. The thousands of *hadith* he studied are not part of the Quran, but they carry the weight of law for many in Islam's global Sunni majority.

Ibn Hajar's encyclopedic analysis, called *Fath al-Bari*—literally "Victory of the Creator," although Blecher prefers the more poetic "Unlocking the Divine Wisdom"—was, in the 1400s, an unprecedented undertaking in Islam. The work was "a monumental intellectual feat that helped reshape the way a religious community viewed its own tradition ... an instant classic," as Blecher described it last year in *The Atlantic*.

Ibn Hajar worked for at least 30 years on *Fath al-Bari*. Officially it was pronounced as complete in 1438 but, like similar works, tinkering continued and the effort only truly ended when the commentator died a decade later, Blecher says. Anything less might be seen as disrespecting the holy text upon which they worked.

Authors of commentaries are "willing to sacrifice their lives for the text and give themselves over completely to that practice," he says.

Aware of Ibn Hajar's notoriously poor handwriting, given his penchant for writing by candlelight, Blecher thought he was looking at a scan of a draft that Ibn Hajar had penned himself decades before his magnum opus was published.

"I thought, 'This is it,'" Blecher says. He saved the file immediately but couldn't yet make heads or tails of it, as it seemed to have been written so quickly that it was hard to decipher.

"I'm thinking that I can't believe what I'm seeing. Part of me is skeptical, because it was too good to be true," he says. "And in a sense it was too good to be true."

When Blecher got home to Virginia, where he was teaching at Washington and Lee University at the time, he studied the PDF more thoroughly. It turned out not to be a personal draft of Ibn Hajar's, but an early version all the same—one that the commentator had dictated to a student.

"It actually documents what the narrative sources had been saying," Blecher says, which is that students would gather around the master and transcribe his oral dictation. "I could see that there were things crossed out and added in the margin."

Most everything that was known about *Fath al-Bari* up to then came from the text itself and narrative sources surrounding it, Blecher wrote in reporting the discovery in 2017, a year after he arrived at GW. Here was an opportunity to study its DNA.

A DIAMOND IN THE ROUGH DRAFT

The unlikely planetary alignment that led to the unearthing of this manuscript, hidden in a repository that had to be sifted through in person, was eclipsed only by the fact that most scholars wouldn't have cared to search for it. Most are interested in completed manuscripts or commentators' own copies, not rough drafts which were meant for private rather than public consumption, Blecher says.

But a final product offers only part of a story.

Michelangelo's Sistine Chapel, he says, wasn't created in a single stroke.

"There's no way he could have painted it in a day, and yet the way in which we interpret it and analyze it is as if that was his plan all along," Blecher says. "Over the course of making it, Michelangelo must have made decisions here and there about what the work meant and

what its composition would be.”

The chapel is a masterpiece, but it wasn't static. It was alive with variables, dead ends, improvisations and false starts.

The same, Blecher says, goes for *hadith* commentaries. He'd known that in theory, but here finally was proof: The commentaries weren't one-offs, but texts that evolved over time.

In reporting the discovery last year in the *Journal of Near Eastern Studies*, Blecher even points out that a close look at just one part of that early text finds 25 percent fewer words than in the same section in the final published *Fath al-Bari*. And this is a text in which even a single word change might wield profound significance.

“These drafts are meaningful, useful and valuable, and give us insight into when these texts are written and the ways that *hadith* are interpreted over time,” Blecher says.

One major difference between the draft found by Blecher and Ibn Hajar's final version relates to an additional call to prayer issued in marketplaces on Fridays. Many Sunnis approved of it, while Shiites saw it as the product of a corrupted text, which had either been transmitted improperly or outright fabricated. At first, Blecher says, Ibn Hajar said the call to prayer was acceptable, without addressing its origins. But in revisions added to the margins decades later, Ibn Hajar laid down “withering criticism of the trustworthiness and plausibility of each [underlying] *hadith*'s chain of transmission” and scolded those who had circulated them, Blecher wrote in the *Journal of Near Eastern Studies*.

While Ibn Hajar had left out those *hadith* in the earlier dictation, Blecher surmises that after he'd later read works in which they were taken at face value, he “decided it was part of his charge” to include them, “if only to unequivocally reject them.”

Blecher's discovery and analysis of the manuscript informed not only the understanding of the *Fath*

al-Bari, but also the much broader pursuit of a book he published last year, *Said the Prophet of God: Hadith Commentary across a Millennium* (University of California Press).

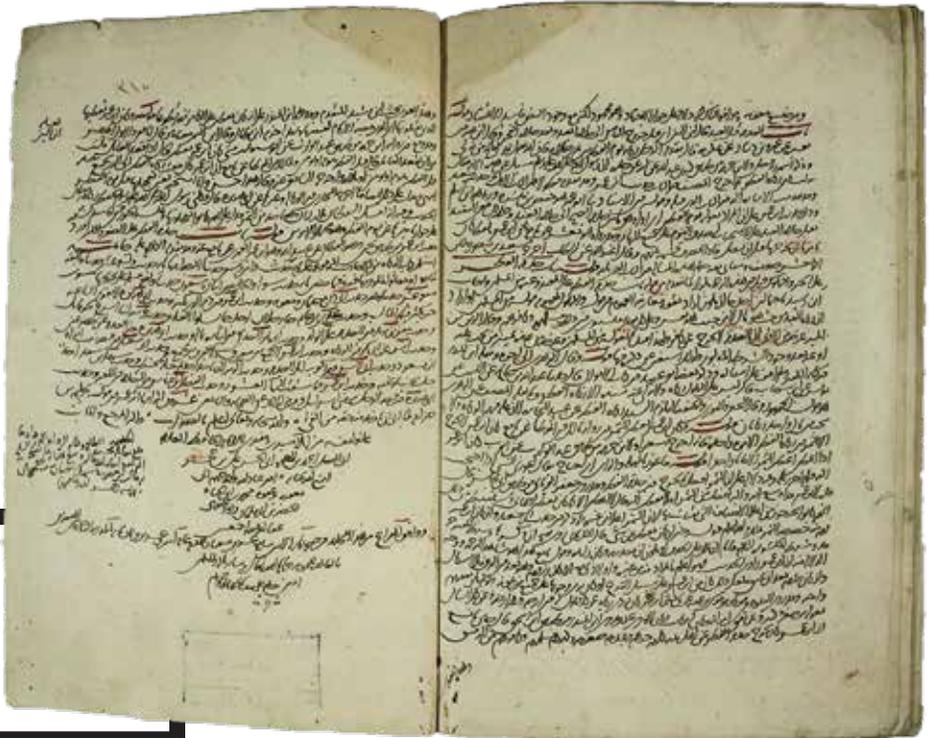
The cumulative work shows the Islamic intellectual tradition didn't become stagnant around the year 1000, as many assume, says Jonathan Brown, the Alwaleed bin Talal Chair of Islamic Civilization at Georgetown University and director of Georgetown's Alwaleed bin Talal Center for Muslim Christian Understanding. Brown is familiar with Blecher's work and

has studied *hadith* extensively.

“Muslim engagement with the foundations of their tradition, and how to bring it to bear on contemporary issues, never stopped,” Brown says.

“*Hadiths* are perhaps the most important source for Islamic law and dogma, eclipsing even the Quran, which is a relatively short text,” Brown says, noting that Blecher's reading of the *hadiths* is novel, but not as controversial as it may seem: When looking for rationale to innovate, Islamic commentators have tended to locate new approaches within earlier

In reporting the discovery last year in the *Journal of Near Eastern Studies*, Blecher even points out that a close look at just one part of that early text finds 25 percent fewer words than in the same section in the final, published *Fath al-Bari*. And this is a text in which even a single word change might wield profound significance.



Folios from the 1419 manuscript showing marginal notes that are described as being added in 1446, updating it to reflect a later pre-final version

discussions. Commentaries are great sites to chart that change.

Deep dives into the commentaries, their iterations and their authors can offer context to help understand those shifts, digging into things like the weight of social and intellectual pressures (even Ibn Hajar sought to shield himself—by recording meticulous notes on dates of dictations, among other measures—from a cross-Cairo rival he suspected of spying in an attempt to scoop him on the project) and the impact of economic factors and patronage on these religious texts.

The last two are consistent threads in Blecher’s work, and ones he’ll carry into his next book, about the intersection of the spice trade and sacred commentators—a project that’s already garnered grants from the National Endowment for the Humanities and the American Council of Learned Societies.

In *Said the Prophet of God*, Blecher tracks the evolution of commentary surrounding one economically oriented *hadith* in

particular, which states that slave owners must clothe and feed their slaves as they clothe and feed themselves.

The *hadith* stems from a close companion of the prophet’s, named Abu Dharr al-Ghifari, who was seen walking with his slave, and the two were dressed in nearly identical garb.

“When asked to explain this unusual practice,” Blecher writes, “Abu Dharr confessed that he used to abuse his slave until Muhammad scolded him, stating, ‘Those whom God has placed under your authority are your brothers. He who possesses his brother feeds him what he feeds himself and dresses him in what he dresses himself.’”

Over the centuries, commentators have vacillated on how to interpret it. In the 11th century in Andalusia, one commentator ridiculed the idea of dressing and feeding slaves as if they were above their stations.

“Slave masters, in his opinion, were required only to meet their slaves’ basic necessities: cover their nakedness and feed them when

they are hungry,” Blecher writes. “It would be absurd, he contended, for any legal scholar to require a slaveholder who ate rare fowl and Persian bread made from the finest flour, who dressed himself in elegant garments from far-away Nishapur, to feed and dress his slave in the same fashion.”

Ibn Hajar, on the other hand, landed on the side of absolute equity on this point, while other’s interpretations across time have advocated for a middle road. Much more recently, in 1999, a Pakistani commentator explained the *hadith*, in the absence of slaves, in terms of equality between capitalists and “labourers who work in factories, shops, and homes,” Blecher writes. And ISIS has embraced it, along with other texts, as a justification of slavery.

ARGUMENT IS A ‘MERCY’

The system of *hadith* and its interpretation that Blecher charts—a jungle of branches and vines coalescing and intertwining—gains even more complexity by aiming to codify and preserve



contradictory interpretations of the same text.

But all that has led Blecher to see *hadith* commentaries as a “kind of time travel,” he says. “They’re bundling these commentaries together. They themselves know that 600 or 700 years separate them and the compilation of the text, and they imagine that their commentary may have to endure for another 200, 300, 400 or 500 years.”

To explain the benefits of debate and multiple interpretive traditions, Blecher quotes a *hadith*: “The differences of my community are a mercy.”

He interprets that to mean that the doubt, skepticism, change and evolution inherent in the interpretations over centuries are part of the divine plan, as the devout see it. The arguments themselves are wrapped up irrevocably in the tradition itself.

“It’s not that you are treating the religious text as a toy or device to play around with the meaning, to make it say what you want it to,” Blecher says. “You are interested in making fine distinctions precisely

because you don’t want to claim to speak for the text and to get it wrong. In a sense, the more seriously you take a text, the more serious you are to make sure you understand the range of possible opinions and meanings.”

By quoting and preserving mainstream positions alongside the outliers, *hadith* commentators essentially delineate the contours and the distribution of the entire breadth of the tradition. The cumulative tradition acts as a check and balance.

“It vets out extreme opinions,” he says.

“Part of what I’m doing in the book [*Said the Prophet of God*] is giving a window into how initiates, or insiders, understand the tradition,” Blecher adds. “It’s often the case that when insiders present their tradition to outsiders, they like to present a unified consensus and a stable, foundational text that’s uncorrupted and an opinion that can’t be challenged. Part of what this book is about is giving scholars some insight into the internal dynamics.”

That includes, he noted in his *Journal of Near Eastern Studies* article, a lingering sense of “the artifice of completion.” He argues, instead, that seeing “a commentary and its revision as a serial performance” can offer a “stereoscopic” view that adds dimensions of time and social and intellectual processes to a text that otherwise might seem to have been hatched whole.

“With each word dictated,” Blecher writes in the case of Ibn Hajar, “and each explanation inked on paper, new riddles, new debates and new ambiguities emerged both for him and his readership.”

Blecher is finding some of the same for himself, even as he operates a few steps removed—digging, as he is, into the *process* of digging into the religious tenets.

After his piece in *The Atlantic* published last year offering insights into the discovery, Blecher noticed an unauthorized, verbatim Arabic translation of his story in an online publication. Then a television anchor in the Middle East posted it on his Facebook page and a bit of a debate ensued as the article spread through 8,300 shares and more than 22,000 views.

“For modernist Muslims and secularized Muslim and Christian audiences, the article seemed to suggest that Islam has the capacity to change as the modern world changes,” he says. “For learned Muslims, who were familiar with the textual tradition, it reinforced something they knew already: that the *ulama*”—or Muslim religious authorities—“have always opened Islamic texts to a wide range of interpretations across time, and that they were always in the process of refining their interpretations.”

Others seemed threatened, and they jumped headlong “into the flame war.” Blecher was called names, he says, and was accused alternately of a plot to distort Islam and of being too generous to the religion.

And the story of history’s interpreters marches on. **BWR**

When a family illness prematurely ended Murray Snyder's career as a submarine commander, he turned to academia. He got his PhD at age 47, and for the past nine years, he's studied ship air wakes for the Navy. The job allows the GW professor to keep helping sailors and lets him go ... // By MATTHEW STOSS

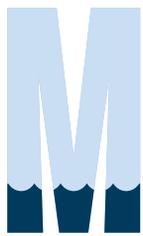
BACK

TO SEA



Murray Snyder aboard the retrofitted midshipman training boat he uses to study ship air wakes





Murray Snyder

remains plainspoken about his research, even in the face of its obvious fun-ness.

A stolid man with a stolid beard and a sense of humor he

doesn't always seem to be aware of, the 58-year-old GW engineering professor studies the air wakes caused by U.S. Navy warships and how those wakes affect aircraft—helicopters, mostly—trying to land on, hover over or take off from those ships. This involves confirming and/or disconfirming a lot of computer flight simulations but, disappointingly, the use of no actual helicopters and no actual warships.

Instead, Snyder and his coterie of researchers fly sensor-rigged drones off the back of a boat—which is still an admirable level of fun, as is the fact that Snyder, a 30-year Navy vet and a private pilot who flies light-sport planes and autogyros, explored the North Pole while serving on a nuclear submarine. But Snyder, disinclined to hyperbole, keeps, at all times, the fun in appropriate (and necessary) perspective.

“The key things I’ve been able to show, using my research ship and lots of tedious data collection,” Snyder says, “is the computer simulations are reasonably accurate for the area immediately around the ship. What we’re working on now is how accurate they are for regions further away from the ship—which is why we have to fly stuff out there. We’ve validated the computer simulations up close, which no one’s been able to do so far.”

The Office of Naval Research has long considered the work of Snyder and his niche field of peers important because it affects how pilots fly and how ships are designed. (Research on the topic, Snyder says, goes back to about the 1960s when helicopters first started landing on ships; the earliest flight simulators came about in the late 1920s.) The ONR has continually funded Snyder for nearly a decade.

At the moment, he’s in the home stretch of a three-year \$655,000 grant and trudging through the applications for two others. Since 2009, Snyder, who started his academic career as a Naval Academy professor in 2006 before coming to GW in 2012, has collected \$2.5 million in funding.

“Folks who have been officers, they tend to have a mission-focused approach to how they do things, which is perhaps not found as much in folks who come from just purely the academic side,” says Can Korman, an associate dean for research and graduate studies who’s worked with Snyder since he arrived at GW. “I think that gives him an advantage. ... And since he has been in the field and he works with people who had other experiences in the field, he understands the needs of the Navy and can appreciate the needs of the Navy from a technical point of view.”

About once a month, Snyder takes his 108-foot ship, a YP boat in Navy argot, out from an Annapolis harbor and into the Chesapeake Bay. This ship, ordinarily used to teach midshipmen to sail, has been converted to a research vessel and retrofitted with an ersatz flight deck so it mimics the shape and the air wakes of a 500-foot warship.

At sea, a professional drone pilot flies one of a number of anemometer-laden unmanned aerial vehicles off the back of the boat. Airborne, the anemometers record the wind speed, direction and temperature as high as 400 feet—the Federal Aviation Administration’s altitude limit for drone flight—above the deck and as far as 400 feet behind it.

Snyder’s drone fleet started with a \$500 remote-control toy helicopter and now is anchored by a seven-foot-wide, 54-pound \$30,000 octocopter that’s festooned with \$20,000 of instrumentation and looks like something that’ll end up doing recon for the robots in the forthcoming machine uprising. (As far as we know, the octocopter is not

yet self-aware.) Snyder also dabbles in fixed-wing aircraft and military drones.

It’s the glamorous side of his work, of which Snyder keeps a less-than-glamorous “humble tape.” In it you can see not only what it looks like to crash \$50,000 into a large body of water but also Snyder’s scientific mortality.

“But,” Snyder points out, “the floatation system worked. We recovered it and washed it with fresh water.”

And replaced all the electronics. And two of the motors.

It costs just \$500 a day for Snyder to boat-and-drone, which perhaps is why the Navy looks so charitably upon his work. To do this research at full scale with a real helicopter and a real warship would cost \$200,000 a day, expenses not included. And that’s if Snyder could even find a warship to borrow. Warships, after all, have stuff to do.

Until Snyder, scientists made do with flight simulators, math and, starting in the 21st century, supercomputers. Snyder uses those things, too, but his niche is defined by the drones and the YP boat and the deep résumé—submarine commander, licensed pilot, a mechanical engineering PhD from Johns Hopkins University—that earned him the imprimatur of the U.S. Navy.

Snyder says none of this was his idea.



ne day during the Vietnam War, Navy helicopter pilot John Burks had to land a chaplain on a destroyer in the middle of a storm. It wasn’t a typhoon but you could’ve fooled the chaplain. It was 1973 and springtime in the Gulf of Tonkin.

“I was taking a chaplain to a small ship for services,” Burks says. “My job was to go and take the chaplain and drop him down on a hoist. You’ve seen the pictures of the Coast Guard helicopters hoisting people up from the water?”

For Burks, retrieving and depositing via winch and cable a serviceman, supplies or mail on the deck of a warship was an everyday operation. Burks would hover his SH-3 Sea King—a 73-foot, 6-ton helicopter the Navy used until the mid-2000s for search and rescue missions and logistics (like the transporting of hapless chaplains)—above a ship too small to accommodate a landing helicopter. Then a crewman would hoist or lower the passenger/victim who was affixed by padded strap (or “horse collar”) to the end of a steel cable.

Strong winds and angry seas impeded the proceeding.

“We typically hovered 15 or 20 feet above the deck,” Burks says. “However, with higher winds and rougher seas, we often had to hover higher. Envision the aft end of this 300-foot-long ship heaving up and down as it plows through high waves—which it must do to maintain control—swaying left and right, and the sides rising and falling as the ship rolls to port and starboard.”

Which means...

“Your landing area is moving back and forth and up and down. At the same time, the wind coming around that superstructure is creating all kinds of turbulence and vortices and it’s making the helicopter rock back and forth in a lot of directions in close proximity [to the ship]. You have to try to pilot it in such a way that you touch down softly and you don’t break things.”

Like a chaplain dangling in a sling at the end of a rope—a God-fearing pendulum swinging in a 25-foot radius across the deck of a several-thousand-ton destroyer that’s moving up, down and side to side, cutting forward at an angle through 12-foot waves. There are also 30 mph’s winds, 50 to 60 mph’s worth of helicopter rotor downwash and the ship’s ever-swirling air wake.

“When I next saw the chaplain,” Burks says, “he said he was praying all the way down. There was so

much movement that the chaplain was swaying from side to side; the ship was swaying from side to side, heaving up towards him, and it took a tremendous amount of skill to hold the helicopter in place and try to get the chaplain on the deck without getting smacked by either side of the ship.”

The chaplain, whom in a likely understatement, Burks called a “good sport,” made it down intact and alive, his faith perhaps reinforced in perpetuity. Burks went on to become a test pilot before retiring as a Navy lieutenant commander in 1978 and joining the Air Force Reserve. He also spent 20 years as an aeronautical engineer at NASA and had two stints teaching at the Naval Academy, where he met Capt. Murray Snyder. Snyder recently had become a researcher and professor after a family illness prematurely ended his tenure as a submarine commander in 2001.

Academia offered Snyder, always scholastically inclined, a chance to stay involved with, and useful to, the Navy. So he went back to school. The Navy bankrolled his doctorate in exchange for his teaching at the Naval Academy when he finished it. Snyder became a professor at Annapolis in 2006 and he got his PhD in 2007. He was 47.

“This was an opportunity to stay in the Navy and do something I thought was of value and productive,” Snyder says.

At the time he met Burks, Snyder, still on active duty, was teaching fluid mechanics and thermodynamics to midshipmen, researching bubbles and droplets in isotropic turbulence—the same topic as his PhD thesis—and running computer simulations on reactive metals. He describes these things as “equally unexciting.”

Burks and Snyder were in different departments but occupied nearby offices. Proximity brokered their relationship, and Burks learned about Snyder’s unique résumé. This, plus his test-pilot past life, sparked an idea that fermented in Burks’s brain for

six months before coalescing into cogency: Snyder could use his rare combination of maritime, engineering and aviation expertise to study ship air wakes, both theoretically and practically, and in the process maybe make life safer for military pilots.

“What really made him suited to do this was his having commanded ships,” says the 71-year-old Burks, who now lives in Annapolis. “He’s a sailor. He knows about ships and so he could request from the Naval Academy that he get one of these ships and really be in charge of a program. They had complete confidence in him doing that. And he was a researcher doing the computational fluid dynamics”—that basically means simulating the interaction between air and an object in a computer—“which is the basis of what the research is, so you don’t always have to go out and do the testing on a ship. You can actually do it in simulation. He was uniquely qualified to do both.”

Burks made his pitch. It was 2009.

“I’ll be honest,” Snyder says. “When this helicopter pilot came in with this idea, I was like, ‘Hey, that’s a lot more interesting than what I’m doing right now.’”

Murray Snyder’s office on the second floor, or “deck” if you used to work on submarines, of Science and Engineering Hall looks like... an office—a standard-issue fluorescent square off a standard-issue fluorescent hallway.

The most interesting things about it are, in ascending order, the bookshelf serving as tabernacle for Snyder’s regally bound PhD thesis, the window overlooking a reasonably grassy courtyard, Snyder’s stacked boxes of research Legos and Snyder himself.

He spent 27 months as commander of the USS *Nevada*, one of the 14 ballistic missile, or “Trident,” submarines that compose the sea prong of the United States’

Navy pilot John Burks lowers a sailor from his Sea King helicopter to the deck of a Navy cruiser in 1973 during the Vietnam War.



nuclear triad. Snyder spent 11 of his 30 Navy years on submarines, serving as a propulsion assistant, weapons officer, engineer and executive officer—one of only two posts that come without a roommate. (He still had to share a bathroom with the captain, though—and his spare bunk, if the sub had a visitor like an admiral.)

In 1998, Snyder became captain of his own ship.

Snyder says he did a lot of “fun” and “interesting” things while serving on submarines, many of which he demurs about because those things are classified. Life on a sub, he says, is cramped, even for someone who’s a svelte 5-foot-9. The beds are 6 ½ feet long and could function admirably as coffins. Even a captain’s stateroom is no larger than an office cubicle. Claustrophobia and the pall of waterborne catastrophe, Snyder says, are mitigated by exhaustion

which, conveniently, also makes it easier to fall asleep. Two decades of submarine conditioning have left Snyder incapable of enjoying any more than an edge-ward sliver of his king-size bed.

Snyder grew up in a military family. His father was a West Pointer and paratrooper but discouraged his son, who was nourishing a lifelong interest in a military career, from attending an academy. The elder Snyder told his son that he’d have more fun at a regular college. Murray Snyder ended up at Duke University, where, he confirms, that he did have fun, before graduating in 1982 with a mechanical engineering degree. Then the Navy commissioned him an ensign and he volunteered for the submarine service, eventually sating a *National Geographic*-inspired childhood fantasy of exploring the icy Arctic in a submarine.

“It is pretty scary up there,” says Snyder, sitting behind his standard-issue office desk and speaking in the tone you and I might use to describe how we boil water. “There are times when you realize you’re really on your own. We were up during the late summer, early fall, when the ice is broken up in places and you have these things called *polynyas*, which is just a lake in the ice.

“You keep track of where you can surface, so if you have a casualty, like a fire or something, and you need to come to the surface to ventilate, you know where you are and where you can do this. ... One of the things you would do on a watch-turnover is, ‘OK, where was the last surfaceable feature?’ And I remember one day, ‘Oh, it’s 250,000 yards behind us,’ which means there’s no way you’re going to get there. It’s just too far away. That’s 125 miles.”

Snyder says that on one

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**IT ALLOWS ME TO GO TO SEA ON A SHIP
AND I LIKE GOING TO SEA ON SHIPS. ...
IT'S A FLEET-RELEVANT ISSUE, AND IN
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THAN I'M AN ACADEMIC.**

submarine (he served on four), he spent eight weeks straight submerged in the Arctic, traversing cold, unknown waters and immured in ice channels.

“The ice gets broken up and it moves around and it has a tendency, if you’re close to land, to build up and get jammed in there—and it gets really deep,” Snyder says. “You can get ice down to 300 or 400 feet under the surface of the ocean. I can remember one night where we’re in a place where the ice was deep and the water was relatively shallow and we came all-stop and the ship was about 400 feet down. I had about 5-foot clearance above the top of the sail and about 2-foot clearance under the keel.”

Going to sea, Snyder says at various, almost regular intervals during more than two hours of in-his-office chats, is dangerous. He stresses, albeit in less alarmist language, that the ocean is an easy

place to die.

“On my first submarine,” Snyder says, “I can remember being 400 feet beneath the surface, rolling 10 to 15 degrees, when a typhoon went over us. Normally when you’re in a submarine, you don’t feel any wave effects below 150 feet but this was like 30-foot waves up there, and I can remember just the whole ship rolling because you have a typhoon above you. But going to sea, it’s a dangerous environment, and it’s nice to see how things to work keep it safe.”

One of Snyder’s more difficult moments as captain came when a petty officer second class suffered a pulmonary embolism. At the time, the *Nevada* was about 250 miles away from its homeport near Seattle and returning from a patrol in the pelagic waters of the Pacific Ocean. Submarines aren’t staffed with regular doctors because the Navy long ago determined that the military equivalent of a physician’s

assistant, a corpsman, sufficed for the medical needs of the average submariner. A PA isn’t qualified to handle a pulmonary embolism, and further miring the situation were the Navy’s rules of waterspace management.

“It’s like air-traffic control,” Snyder says. “Submarines are really quiet, so typically, two submarines, if you put them in the same water, they could hit each other. The bottom line was we didn’t own the water from where we were at to get back to the place where we could put the person in for medical care.”

Snyder had a decision to make: Violate the “rules of the road,” surface and break the 7-knot speed limit or follow those rules and risk a sailor’s life.

“I went 15 knots,” Snyder says. “I made the conscious decision to not follow the rules of the road because I had this guy who was near death. ... I made the conscious decision to drive well above the speed limit for 12 hours or something like that to get the guy off the ship, and we got him off and he lived and we didn’t hit anything—and we weren’t stupid about it. We had extra personnel on watch, extra radar.”

Snyder also informed the Navy of his decision, communicating with doctors on shore, and he made gratuitous use of the *Nevada*’s foghorn. Had he hit something, like another submarine or a merchant ship, he would have been “relieved for cause.” That’s official Navy for “fired.”

“I’ve done a lot of interesting stuff in the Navy,” Snyder says. “A lot of it was fun; a lot of it was scary. But in the end, the people you work with in the military and in the Navy, as a group, are pretty good people.”



usan Polsky has been researching the air wakes of Navy ships since 1999 when she decamped from NASA’s Ames Research Center in California, where she studied hypersonic aerodynamics, to Naval Air Systems Command in

Patuxent River, Md., so she could be closer to her hometown of Rockville.

Ship air wake research had been going on for decades but it never rated enough to be anyone's concentration, always fizzling before the research went anywhere sexy. The technology didn't exist to model ship air wakes, and inevitably, the Navy fell back on the subjective experience of test pilots to develop the parameters (flight envelopes) for the average pilot to safely take off from, and land on, seaships.

The advent of supercomputers in the early 2000s and their comparably super processors changed that.

"Until that time," says Polsky, now a senior computational fluid dynamicist at NAVAIR where she specializes in ship air wake research, "there just simply wasn't enough computational power to do what needed to be done."

The typical personal computer has a single processor. The computers Polsky uses today for flight simulations and the various sophisticated feats of algorithmic legerdemain have hundreds of thousands of processors. A supercomputer in the early 2000s ran on 200 or so processors.

These supercomputers didn't come about because of the air wake work of military engineers. Rather, those engineers—a small band that at the time consisted largely of Polsky and an infant's handful of her associates—saw its application and co-opted the technology.

Polsky, who started off by developing flight simulations for Army helicopters landing on Navy ships, emerged as a pioneer in an invigorated field, publishing her first paper on ship air wakes in 2000. Later, she fit 20-foot poles with ultrasonic sensors and placed them around Navy warships to take air-speed measurements while the ship moved through the water. She ended up with just 20 to 50 data points because of her limited access to Navy vessels—and none of those points were behind the ship or

higher than 20 feet. She also missed out on recording aircraft turbulence, another factor considered when developing flight envelopes.

In almost 20 years of ship air wake research, Polsky says that she's been out on a Navy boat with her sensor poles no more than four or five times.

"We're too small potatoes to do something specifically for us," Polsky says. "The way it's always occurred is there's a flight test going on ... and they don't have anything else going on at the time other than the flight test, so they say, 'OK, we're not doing anything else; we're already stuck because we have to accommodate this aircraft testing, and as long as you don't interfere with this aircraft testing, you can bring your anemometers aboard and collect data.'"

It took someone flying a sensor-loaded drone off the back of a ship to fill in Polsky's research blanks. That's where Murray Snyder and Polsky intersect.

"Murray has added a piece of the puzzle that allows us to have confidence in our simulations," Polsky says. "... We can go in a wind tunnel, but one of the aerodynamic gotchas is that air flow doesn't necessarily behave the same on something you have to shrink down to fit in a wind tunnel versus what the full scale is. This is true for airplanes and it's also true for ships. Murray has been able to give us that access where we can go back and collect more data as we need it. So if we hit some point where we're thinking, *Hmm, the simulation doesn't really compare very well here; we're not really sure why*, we can ask Murray, 'What if you go out and test in such and such conditions?'"

The practical applications of ship air wake research are less than grandiose. Suggesting to Polsky or Snyder that their work prevented an aircraft-to-ship crash—crash statistics are classified by the Navy—provokes a contravening response that is as immediate as it is impassioned.

"I have incrementally helped

them quite a bit," Snyder says. "But please, do not say that I've saved a helicopter—or saved anyone. There's no way of knowing that. Science these days is incremental improvement, and I've helped make a whole bunch of incremental improvements."

Snyder has established more than 190 data points around a warship using his UAV-borne anemometers which measure the space within a roughly 16-centimeter cube of air. He's made flight simulations more reliable by virtue of testing them in praxis and has broadened the qualitative scope of Polsky's supercomputer models. For example, they now have simulations for aircraft as large as the 64-foot, 7-ton H-60 Seahawk helicopter—the SH-3 Sea King's successor. (It's harder to model larger aircraft because they're physically more complex—more bumps, protrusions—and they create their own big air wakes.)

According to Polsky, Snyder's also determined that, despite being designed from the same plans, each ship has individual imperfections that create ship-specific air wakes. Thus far, no boat has been so air-wake terrible as to merit a from-scratch redesign—and no one would design a warship solely with its air wake in mind, either. A ship has too many other superseding duties and functions, especially stealth, which necessitates streamlining and smooth surfaces, both things that exacerbate air wakes. But Snyder's research, concomitant with Polsky's, has led to occasional tweakings, like moving a gun turret to act as a windbreak.

It's all stuff no one would know if not for the drones and little boat of Murray Snyder the Reluctant Academic.

"The issue is of interest to me because it's something that impacts sailors and ships," Snyder says. "It allows me to go to sea on a ship and I like going to sea on ships. ... It's a fleet-relevant issue, and in the end, I'm a Navy officer more than I'm an academic." GWR

*HOW THE
VICTORIANS
CHANGED
MEMORY*

*BY
MATTHEW
STOSS*

JENNIFER GREEN-LEWIS has a Victorian interest so pronounced, it might be a lifestyle. ¶ The Surrey, England-born and Suffolk-raised GW English professor is descended from Victorians—her grandparents were born in the 1880s—and today she teaches courses on the Victorian novel as well as Modernism (Green-Lewis also has a thing for Virginia Woolf). ¶ Green-Lewis has authored three books—two on the Victorian era, including 2017’s *Photography, Literature and the Invention of Modern Memory* (Bloomsbury). In April, she chatted about the book and how the invention of photography in the 1830s makes us more intimate with the Victorians, the first photographed generation in history, than with anyone else who lived and died before.

This late 1830s photo by Louis Daguerre, *Boulevard de la Temple*, is considered the first candid picture of a person.





WHY DOES THE INTERSECTION OF THE VICTORIAN ERA AND PHOTOGRAPHY INTEREST YOU?

I feel like I was raised by post-Victorians, essentially, because our entire library at home was what we inherited from my grandparents. I grew up reading Andrew Laing fairy books and *Sara Crewe, or What Happened at Miss Minchin's*, which in America was published as *A Little Princess*.

And in my father's study, that's where all our old photos sort of went to die, and we had a lot of family photos—photographs from my family's army life in India going back to about 1840. So I grew up looking at photographs a lot.

Victorians were the first people in history to be visually available to us on our own terms. Yes, I was drawn to the Victorians because of photography. I didn't think so at the time but I look back now and I think that's what it was. The fact is we didn't have paintings of our ancestors but we had a lot of photographs of our grandparents and great-grandparents—I have them now—from the 1850s, '60s, '70s, right through to the '20s when they came back from India.

WHAT IS IT ABOUT THOSE PHOTOS THAT GOT TO YOU?

There's this kind of tension when you look at a photograph of someone. At a certain point, your eyes meet.

[French philosopher and critic] Roland Barthes [1915-1980], I think it was, reproduces a picture of [Lincoln assassination conspirator] Lewis Payne, who's a prisoner and he's going to be executed, and the caption is: "He is dead and he is going to die." He's already dead by the time you look at him because of course it's an old photograph and he's been dead for decades. But he's going to die because, remember, when you look at him, he's actually still alive. It's very interesting, that

sort of temporal slippage. I think that's why I drifted towards Virginia Woolf and became not just a Victorianist but a Modernist as well.

HOW DOES VIRGINIA WOOLF FIT INTO ALL THIS?

She's so interested in moments where the past and present—it's not that they collide; it's just that they're so much a part of each other that we really can't differentiate between them. You can't differentiate at the level of style or grammar.

So here's something that I was teaching the other day. We're looking at a passage and there was this word "now" that kept coming up. "Now, now, now, now." And I was saying to this student, "Well, does 'now' mean now or does it mean then?" You know, "I can see her *now*." What does that actually mean?

If you said to me, "Now I'm thinking of my grandmother, who's been dead for 20 years, but I can see her now," I don't take you to get you checked into the local insane asylum. I understand that you're using the language metaphorically, and when you say, "I can see her now," you mean, "I have an image of her in my mind that makes her present to me." You don't say that; you just use the language of presence. And that's what photography is, and I'm just completely fascinated by the way that, especially now, it's so much a part of people's intuitive sense of time passing.

IN YOUR BOOK, THERE'S THE 1858 PHOTOGRAPH BY HENRY PEACH ROBINSON, FADING AWAY, THAT SHOWS A FAMILY GRIEVING OVER A DYING TEENAGE GIRL—EXCEPT THE PHOTO IS STAGED. THIS CAUSED A MINOR OUTRAGE BECAUSE IT FAKED WHAT AT THE TIME WAS A COMMON PRACTICE: PHOTOGRAPHING THE DEAD.

He claimed that he made it to see how near death he could make a fine, healthy 14-year-old look. But he touched a nerve with the subject matter. It was far too close to the bone for many people, and when they learned that it was staged, like a theatrical tableau, and that the people in it were acting, some viewers were intensely offended. Was it theater? Was it art? What was a photograph if it wasn't true? They weren't sure how to evaluate it.

WHAT DO YOU THINK ABOUT THE VICTORIANS PHOTOGRAPHING THEIR DEAD?

What's interesting is that that practice of photographing the dead is actually coming back. A friend of mine recently showed me a photograph she'd taken of her cousin in his coffin. Apparently it's not unusual now to do that in the funeral home. Of course, we have a compulsion to take photographs always and everywhere. But the thing that really interests me is the sense the Victorians obviously had, and that we do, too, that postmortem photographs give some kind of special access that a sketch somehow can't. That's what Barthes talks about—the thing that's peculiar to a photograph, its indexicality; what he calls the "that-has-been" of the photograph.

It's the idea that a photograph is in some way like the fingerprints of the sun—remember an early word for photography was heliography, or light-writing. Whether you buy that idea or not, there's something weirdly intimate about a photograph that makes the complexities of human presence visible. I have a picture on my office wall of Queen Victoria in her coffin, so I guess I'm not immune.

IT MAKES SENSE, THOUGH. GIVEN THIS NEW WONDER TECHNOLOGY THAT CAN DOCUMENT ANYTHING WITH 100 PERCENT ACCURACY, THE FIRST THING YOU'D DO

IS MAKE A RECORD OF THE THINGS MOST AT-RISK OF BEING GONE.

I'm actually thinking about Virginia Woolf, because in a novel like *To the Lighthouse*, she really explores the liminal space in which somebody has died but is also present—in the memories and dreams and language—to such an extent that we can't meaningfully say that the person is absent. They have some kind of presence that I think is understood. When we use the metaphor of photography, it gives us a way of understanding that presence is also absence. I mean, you don't need a photograph of someone that's actually with you, right?

In the mid-19th century, someone would give you a photograph of themselves because you weren't going to be there. So the photograph was a way of marking absence—but also social presence. So there's that paradox.

If you show me a photograph when you were a child, you'd say, "Here I am. I'm 3 in this picture." Instinctively you move into the present tense; this is the pictorial present tense.

HOW DID THE VICTORIANS REACT TO HAVING THEIR PICTURES TAKEN?

Well, it was a much bigger deal than it is today! For many people it was a formal event, to get dressed up and go to the studio to get a daguerreotype made. And in the early days, it was a real ordeal involving long exposure times and head clamps and sitting for ages being absolutely still. And philosophically it was problematic for some people. [Charles] Dickens supposedly hated getting his picture taken. Elizabeth Barrett Browning found photography very intimate; photographs gave her a "sense of nearness." But that nearness could make it feel vaguely indecent to hand over your image to someone and let it loose in the world.

[Thomas] Hardy writes about that in *Jude the Obscure*. We're still grappling with that today, too. But to many people, it wasn't so very different from giving someone a piece of jewelry made of hair; a photograph was personal, like a body part perhaps, but it also made sense within Victorian culture. They were used to memorializing the body, if you think about it—casts of hands and so on. Baby shoes. Death masks. Animal hooves turned into inkwells, that kind of thing.

DOES OUR HABIT OF CONSTANTLY TAKING PHOTOS OF EVERYTHING AND POSTING THEM ON THE INTERNET AFFECT HOW WE VIEW OR RELATE TO THE VICTORIANS?

I would say that in our present moment we are better equipped to understand the Victorians than we have ever been because we are, again, at a moment where we're really thinking about our relationship to the passage of time, and we're marking it, or if we're not thinking about it, we're naturalizing it. So we're just sort of doing this thing that feels almost instinctive. The Victorians were starting to record their histories and the passage of time but didn't really have a language for it. They didn't know how to talk about it, as you saw when you looked at the *Fading Away* stuff.

I'm really interested in the way in which our modern moment—the moment of social media, digital photography—how that gives us a very different way to think about the Victorians but allows us, I think, to understand them better.

I see the movement from the earliest days of photography in the 1840s to where we are now as much more a natural evolution of the desire to narrate time, and people do argue that in fact technology makes it a whole different beast, that it's a completely different animal, that digital photography



Jennifer Green-Lewis

is nothing to do with analog photography; they're very different. I don't see that because I'm so interested in function, in how it works rather than what it is. I think that this is the same impulse that leads you to Instagram or to check your phone, to taking photographs. It's the same impulse as picking up your Brownie camera in the 1890s, or going back to the 1840s and spending half an hour wrestling with some great lumbering thing to take somebody's portrait. It's the same impulse to engage with our mortality, essentially.

I THOUGHT ABOUT STEAMPUNK WHILE READING YOUR BOOK. IT'S UNIQUE IN SCIENCE-FICTION BECAUSE IT'S COMPLETELY DEFINED BY A SINGLE SPAN OF TIME: THE VICTORIAN ERA. I WONDER IF IT'S BECAUSE THE VICTORIANS WERE THE

FIRST GENERATION TO BE PHOTOGRAPHED AND THAT BRANDED THEM IN OUR IMAGINATIONS.

Yes, I think that's the fundamental shift because you can actually have access to your physical past that you never had before. We can look at it in terms that are familiar to us. We think of those terms as belonging to us, but they don't belong to us. They were actually crafted by the Victorians. They were refined by them. I think that when people think about the past, quite often what they think about is the 19th century.

What I'm really driving at is the technology is what gives us that new sense of absence that we just didn't have before 1839, 1840. If you had access to the past, it was because you had social privilege.

THERE'S ALSO THIS IDEA OF A SUBJECTIVE REACTION TO AN OBJECTIVE THING

AND PLAYING WITH THAT DYNAMIC. THAT'S WHAT HENRY PEACH ROBINSON DID.

That's what draws me toward Virginia Woolf. Because she's post-Victorian, cerebral, modernist, you would think in her writing you'd find no interest in things, but her world is full of teacups and gloves and stockings and scarves and shawls and the material objects of everyday human life. In Woolf, it's through objects that we access people who are no longer present to us. Photography does something similar. It memorializes people in part by generating tangible objects, household items, that acquire significance over time and become part of that material inheritance—a Victorian inheritance, for Woolf. And she inherited some really fabulous photographs made by her great aunt, [photographer] Julia Margaret Cameron. Woolf once said that she always started her writing with an image in her mind. And of course, as a post-Victorian writer, as someone born in the age of photography, that image might very well be a photograph. That's pretty much what I write about in the book: the way that the Victorians remembered, it's how we remember now.

GOING FURTHER, WHAT ABOUT PHOTOGRAPHY AS IT RELATES TO A PERSON'S PERCEPTION?

Recently, I've gotten interested in the instability of the perceiving subject—by that I mean, of the person who's actually doing the looking; the one who's reading the photograph. One of the weirder things about mid-Victorian culture is the experience that people had putting their eye to a microscope—the parlor game of having your own microscope, and the game of using microphotographs where you get a photograph of, say, a text of Dickens or some other oddity or curio, and then you put it into your microscope and you look at it and you can blow

it up.

It's silly. We look at it and we think: *What was the point of that?* And there was no point. It was a game. But the fad lasted for a couple of decades. Lewis Carroll had a collection, and this is a fact that's really interesting. Actually on the very same day that he took the Liddell girls out on a rowing boat in Oxford and told them this story of Alice's adventures in Wonderland ... at 8 o'clock at night they got back and went to his rooms, and in his diary it says, "And I showed the girls my collection of microphotographs." What that means is that Alice had to put her eye to the microscope and blow this miniature world up. And who knows what these microphotographs were of. But they would have been something very tiny that you would then make big—or it might have been like the reverse, which is not microphotography but photomicrography, where in fact what you're looking at is a little foot of a spider blown up to be big, or something like that.

So what you've got is what I call an unstable sense of self in relation to the world. That is actually the story of *Alice in Wonderland*, right? She gets big; she gets really small. But the part of the lived experience of the mid-Victorian, that is peculiar to the Victorian and had not existed before, is that sense of the self in relation to the world that is tempered by photography, by the lens, by microphotography, photomicrography, by the experience of putting your eye to the lens and seeing the world in a different relation.

VICTORIANISM IS PRETTY POPULAR TODAY. HAS IT ENDURED OR DID IT HAVE TO MAKE A COMEBACK?

I think it was for a surprisingly long time considered very bad taste to enjoy the sentiment of the Victorians, and I think that's one reason why Victorian art was relatively unpopular for much



of the 20th century. I remember when I was a child, my parents had no time for anything Victorian. The word most frequently used with the word "Victorian" would be "monstrosities." So they were talking about anything architectural—*Victorian monstrosity*. Or Victorian decor. They thought it was over the top and very tacky.

The Victorians are sentimental because they're interested in the emotional life of their characters.

This 1858 picture by Henry Peach Robinson, *Fading Away*, subverts the Victorian death photo. The sick girl is actually healthy.



I think I'm defensive of that in a way because it seems to me that if you [ask] most people, they're actually quite interested in the sentimental lives of characters and the emotional goings-on. It's just that there's such a radical shift away from that later.

WHEN PEOPLE START SUBVERTING SOMETHING VIEWED AS AUTHORITATIVELY OBJECTIVE, DOES THAT

CHANGE HOW PEOPLE APPROACH PHOTOGRAPHY? AGAIN, THE FADING AWAY PHOTO.

Yes, I think so. The subversion that's implicit in art photographs like *Fading Away* certainly opened up more space for arguing about photography, for redefining it. There was a lot of vigorous debate about it after it was first exhibited. I suppose in a way you could say that Robinson aimed to free

photography from documentary servitude, but he was still really interested in representing the truth about life as he saw it. He thought that photography as art could actually serve a higher truth than the documentary one. It's a mistake to assume that the Victorians had a total commitment to the photograph as a document, that they weren't aware of the potential for play and trickery and faking and for taking artistic license. BWR



The KNoNap changes color when it comes into contact with a drink that's been tampered with.

INVENTIONS

POCKET PROTECTOR

An undergraduate's cocktail napkin that combats date-rape drugs gathers awards and momentum on the way to launch.

// By Kristen Mitchell

Lately, Danya Sherman spends her time between classes on the phone with distributors and business executives. She's formulating a plan to launch a company that she hopes will empower her peers against drugged assault.

The company revolves around Sherman's KNoNap, a cocktail napkin she developed that will detect the presence of date-rape drugs in a drink. If the napkin comes into contact with a drink that's been tampered with, it changes color.

Since she first pitched KNoNap in 2017 at GW's New Venture Competition, Sherman's life has

radically changed. She has received funding to continue her work, been honored as a top student entrepreneur in the U.S. and made plans to launch a Kickstarter campaign to bring her product to market later this year—all while balancing life as a full-time undergrad in the Elliott School of International Affairs.

The endeavor and its educational mission was born out of personal experience. Sherman was studying abroad when a friend slipped drugs into her drink and took advantage of the situation. She decided then she wanted to create a product that would empower individuals in social settings, and ensure they didn't have to choose between their social comfort and welfare.

Sharing her story and hearing from others, she says, has been a humbling experience; it highlights how much work needs to be done.

"We are so proud of KnoNap because it can be seamlessly incorporated into any social setting and used by anyone regardless of gender and sexual orientation," Sherman says. "What I want my company to do is join the movement of individuals, thought leaders, survivors and advocates to say: Enough is enough, and something has to change."

Part of Sherman's long-term goal is to partner with universities, Title IX offices and police departments to increase education around drug-facilitated assault.

"You cannot protect yourself against an issue [with] which you are not familiar," she says.

Before starting KnoNap, Sherman didn't see herself as an entrepreneur. Her parents encouraged her to enroll in a Women's Entrepreneurial Leadership Initiative course in the spring of 2017.

Having the space to put her thoughts on paper and to create a business plan changed her life, she



Danya Sherman

says.

That year, Sherman entered her proposal in the New Venture Competition, where KnoNap took home \$10,000, along with in-kind prizes, as a finalist and winner of the Audience Choice Prize. Sherman went on to win the \$2,000 first-place undergraduate award and a \$500 audience choice award in that year's Pitch George Competition.

The company quickly began gaining traction. Sherman was named a 2017 fellow at the Halcyon Incubator, a Kairos Fellow and was recognized as one of *Washington Life* magazine's 2017 Tech 25 Innovators and Disruptors.

Then this year she was awarded \$50,000 as one of Toyota's "Mothers of Invention," she represented the U.S. at the Entrepreneurs' Organization Global Student Entrepreneur Awards and has been getting press in local and national news outlets,

from *Washingtonian* magazine to *Glamour* and *Newsweek*.

In the meantime, Sherman is learning to adapt to a new normal, including the long nights and early mornings she's putting in to bring her ideas to fruition. As the head of the company, she's learned to enjoy the successes, learn from the failures and, in either case, to keep pushing forward.

Sherman likes to say that KnoNap is first and foremost a safety company that uses napkins as a vehicle. And in an environment in which most startups fail, that flexibility may prove to be a key to success.

"I didn't fall in love with my product, I will fall in love with our mission," she says. "I will do whatever it takes and pivot and iterate to make sure that the products we're putting out will be successful so that we can achieve our mission." BWR



ENTREPRENEURSHIP

TURNING THE TABLES

A restaurant waitlist innovation and other budding businesses vied for \$330,000 in cash and in-kind prizes at the annual New Venture Competition.

// By Briahna Brown

The grand-prize winners of GW's New Venture Competition aim to redefine the dining-out experience by taming one of its big frustrations: the wait to getting a table.

The team of Jonas Majauskas and Jason Korneich, seniors in the School of Business, and their business partner, Giuliano Senese, explained at the competition's final round in April that their business, Time Table, works with restaurants to streamline the waitlist process.

Using a chatbot in the Facebook messenger app—and, eventually, they hope, other mediums like Amazon's virtual assistant,

Alexa—users are added to partner restaurants' waitlists through the app, rather than having to call or show up to be placed on the list. And wait times are calculated in real time, helping diners avoid being told to wait 20 minutes for wait time that's actually more like 40 minutes.

"In essence, what we're doing is replacing these buzzer systems or the outdated pen-and-paper system," Mr. Majauskas told the judges. "There's no need to have that initial interaction with the host or the restaurant. It's all done through Facebook messenger."

The team—which already has

partnerships with nearly three dozen restaurants in the New York City area and 200 beta-testing diners—took home the \$25,000 grand prize as well as prizes for Best Tech Venture and Best Undergrad Venture.

Time Table was among nine teams in the New Venture Competition finals—winnowed from a starting pool of 137 teams—vying for \$330,000 in cash and in-kind prizes. Over the past decade, the competition has awarded more than \$1.5 million in prizes.

In a keynote address, Florida Gov. Rick Scott—a former GW

RIGHT Florida Gov. Rick Scott
LEFT, CLOCKWISE FROM TOP
Andrea Armas of Sumak;
Sahil Pankhaniya of George
Washington University Credit
Union Initiative; Neha Jog of
Sisterly Questions; and John Kuhl
of Bendt





parent who, along with his wife, Ann, had made a founding contribution to the competition and a 10-year pledge—discussed some of his own business ventures, like manufacturing, pharmacy chains, and urgent care and hospital companies. He learned a lot about building a successful business, he said, but the best part has been all the people involved.

“You get to meet these unbelievably wonderful people that you get to work with and as you develop a team and the comradery of putting something together and then busting your rear to try and figure out if it works,” Scott said. “It’s so much fun to try to do that.”

The competition’s second-place winners were Jelena Jeremic, a graduate student in the School of Business, and her business partner, Katya Vert, the team behind Nostopharma, a company that developed a medical treatment to prevent pathologic bone growth that can occur after trauma or severe burns. They also won the prize for Best Women’s Venture.

The Wandering Raven, an e-learning platform that aims to teach children in India creative writing skills through animated videos, was the third-place winner. It was created by Trishanya Raju, a student in the Graduate School of Education and Human Development, along with her business partner, Mayank Mathur. They also won the prize for Best International Social Venture.

Fourth place went to Sassy Pants, which aims to empower women through innovative and customizable athletic apparel. The team behind the brand is Elizabeth Terry in GWSB and Erin Oliphant in the Colombian College of Arts and Sciences, along with their partners Nancy Calderone and Tamara Wurst. GWR

THE 9 FINALISTS

DiStat: The Rapid Diagnostic Suite is an on-site, on-demand clinical testing solution, saving time and money for healthcare businesses and consumers. Led by: Isaac Lichtenstein (SMHS ’20); Spencer Lichtenstein

Nostopharma: Develops treatment to prevent pathologic bone growth, a painful complication after traumas and severe burns affecting 100,000 patients. Led by: Jelena Jeremic (GWSB ’21); Katya Vert

Time Table: Aims to redefine the dining experience by integrating automation, increasing calculation accuracy and streamlining the waitlist process. Led by: Jonas Majauskas (GWSB ’18); Giuliano Senese; Jason Kornreich (GWSB ’18)

Bendt: A distributive risk-mitigation platform that facilitates the trading of future earnings of professional athletes to produce tracking stocks. Led by: John Kuhl (GWSB ’18); Rem Houghton (SEAS ’18); Samuel Bamiboye

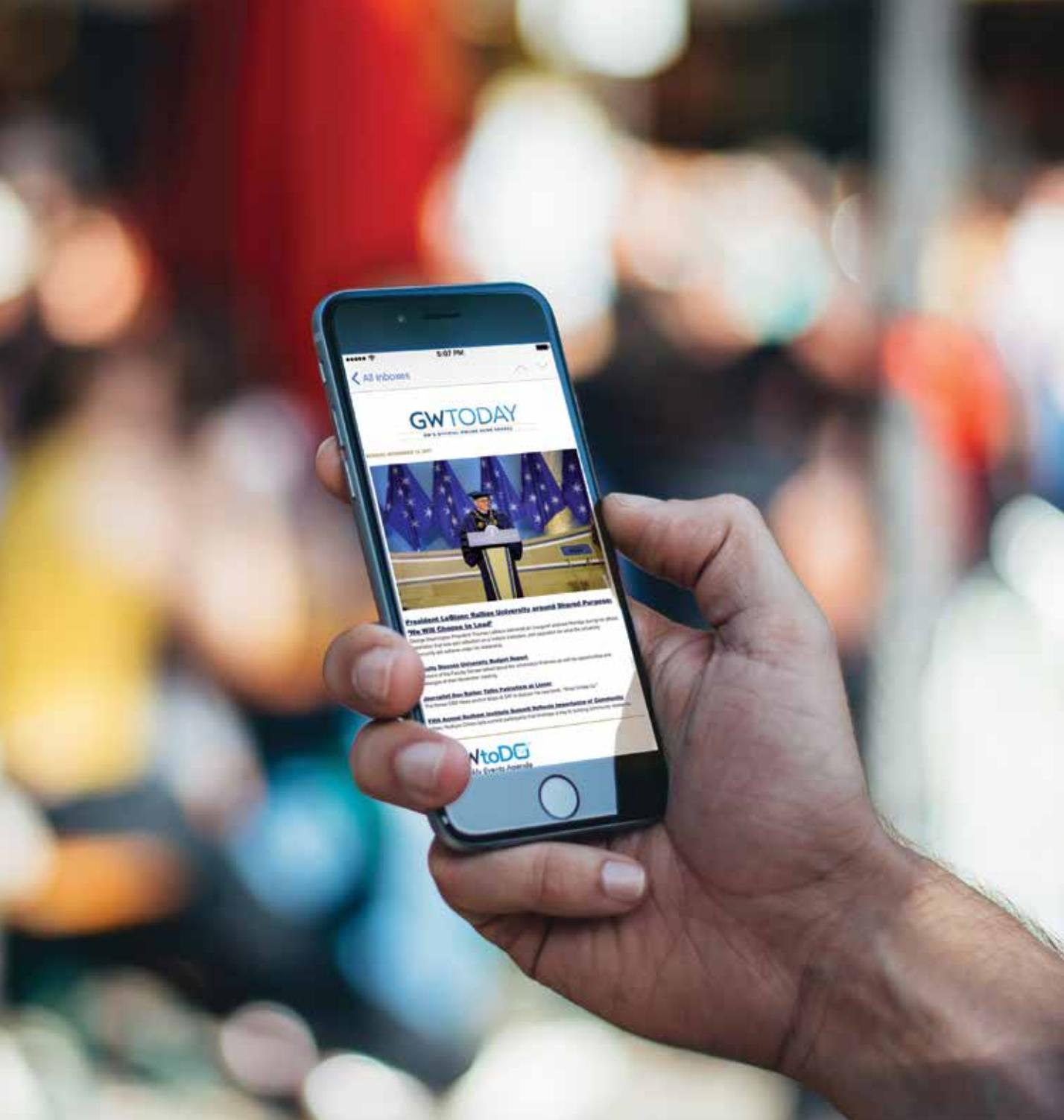
The Wandering Raven: An e-learning platform that teaches young students creative writing through informative and engaging animated videos. Led by: Trishanya Raju (GSEHD ’19); Mayank Mathur

Sassy Pants: Empowers women by co-creating innovative, customizable athletic apparel to transform traditional fitness. Elizabeth Terry (GWSB ’19); Erin Oliphant (CCAS ’19); Nancy Calderone; Tamara Wurst

Sisterly Questions: An online information and support system that acts as a virtual big sister and a curriculum provider. Led by: Neha Jog (CCAS ’20); Sarah Stupp (CCAS ’20)

Sumak: An Andean healthy beverage based on purple corn that contains antioxidants and phytonutrients, created for and by women. Led by: Andrea Armas (CPS ’18)

George Washington University Credit Union Initiative: A credit union that aims to strengthen the GW community by helping students bank cheaper, build credit and learn to manage their finances. Led by: Sahil Pankhaniya (GWSB ’21); Chris Trummer (SEAS ’21); Allen Wang (GWSB ’21)



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