GW RESEARCH

THE GEORGE WASHINGTON UNIVERSITY

SPRING 2014

THE SEARCH FOR THE ORIGIN OF LIFE

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ANCIENT CANAAN'S BLANK CANVAS

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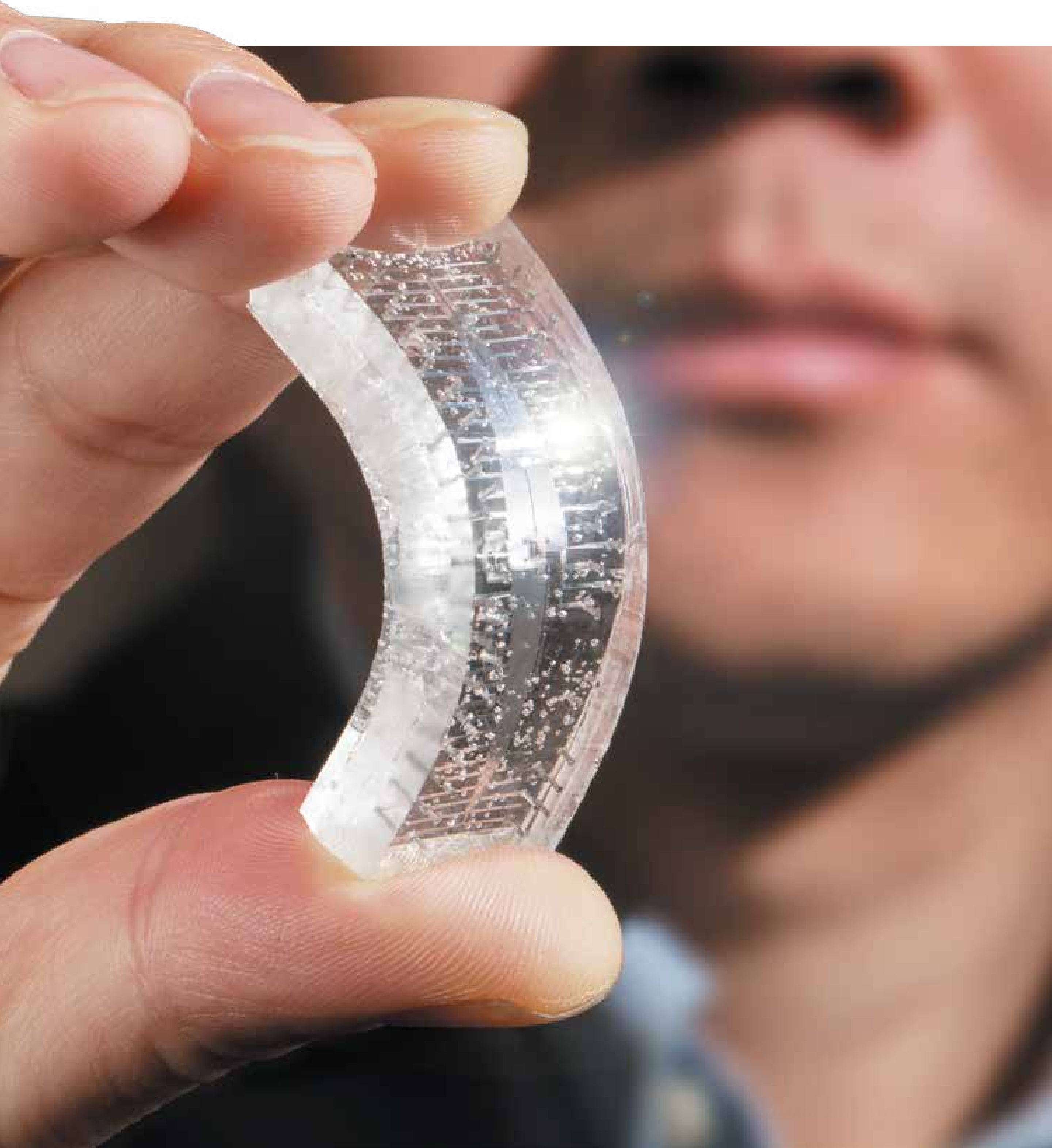
FLEXIBLE ELECTRONICS



OPENING DOORS

There was a timid knock at the door.

It was late one evening in 1978 at the Cambridge University physiology lab where I was on a fellowship, studying vision. Opening the door, I saw an older gentleman. He apologized for the disruption and asked if I'd mind if he had a look while I conducted my work.

I didn't mind, and so he stayed for a bit.

"I heard Francis came to visit you last night," the head of the lab said the next morning.

"Francis?"

"Yes," he said. "Sir Francis Crick."

Dr. Crick, who helped determine the double-helical structure of DNA, was pursuing an interest in neurobiology at the time and, apparently, would pop into that lab at his alma mater now and then to see what was new.

The point: Anything can happen in a lab—including chance encounters.

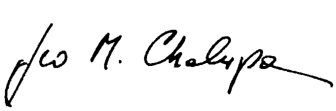
It's a spirit we're embracing at GW, particularly with two new teaching and research facilities designed to spark ideas and unforeseen collaborations that bridge disciplines: our 14-story Science and Engineering Hall, which in less than a year will bring under one roof researchers ranging from computer and aerospace engineers to biologists, chemists, and physicists; and the first permanent home for the faculty of our Milken Institute School of Public Health, the only public health school in the nation's capital.

That's not to say that we're leaving it all up to chance. We're making our own luck, bringing together thinkers from across GW through a slate of universitywide research institutes.

This winter we launched a Sustainability Institute, helmed by a former deputy secretary of the U.S. Department of Agriculture. It joins our recently established Computational Biology Institute and Global Women's Institute, and we're in the midst of planning for future institutes that will tackle, among other areas, genomics, autism, and "big data," comprising almost unimaginably vast and enormously complicated sets of information.

More than two decades after my encounter with Francis Crick, he agreed to co-author a chapter in a book I was editing, published in his final year of life. I can only hope the connections between researchers here will be just as pleasing and long-standing, and their fruits even more enduring.

Sincerely,
Leo M. Chalupa



Vice President for Research

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For correspondence or change of address, please write us at resmag@gwu.edu.

JESSICA MCCONNELL BURT

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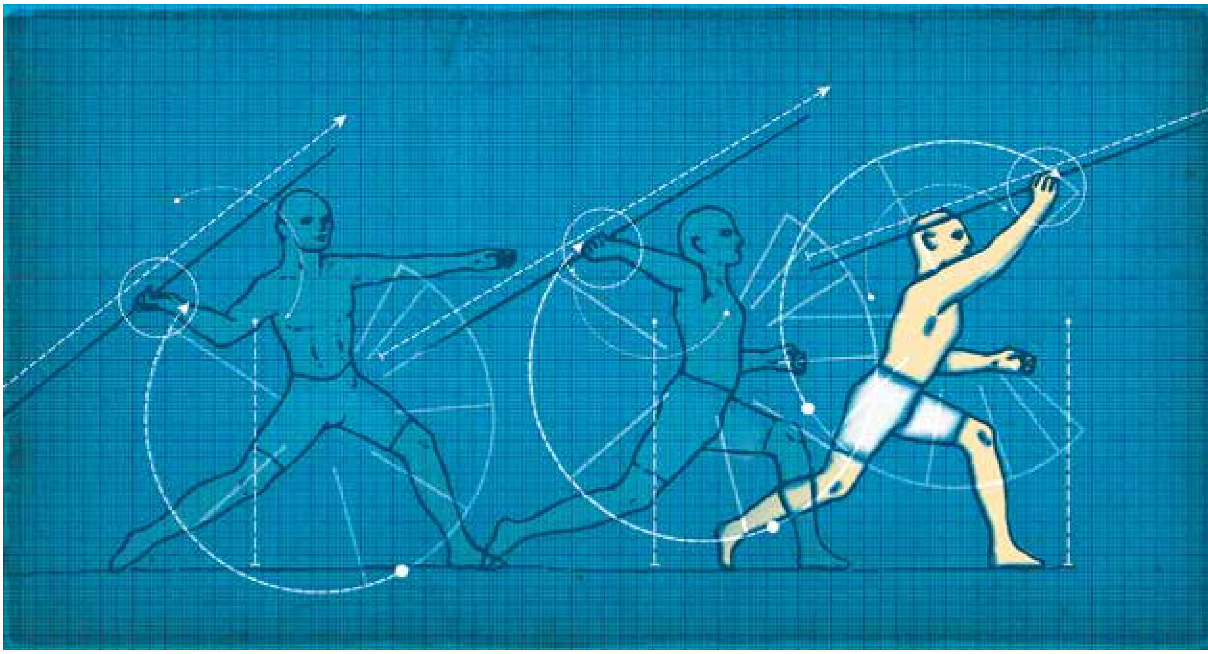
JESSICA MCCONNELL BURT

Front and back covers: Researcher Zhenyu Li demonstrates a bendable, stretchable electronic device he and two GW colleagues are developing for medical diagnostic use. Beneath a microscope, a network of liquid metal-filled tunnels—the wiring—to the chip is visible in detail. Photos by William Atkins



ORIGINAL ART: NATURE/LASZLO MESZOLY; ILLUSTRATION: JESSE WINSTON, JOHN MCGLASSON

EVOLUTION

UNWINDING THE ORIGINS OF THROWING

Key anatomical changes first appeared together 2 million years ago

Modern man may have perfected the fastball, but it was our ancestors nearly 2 million years ago who likely were the first to throw it, according to a recent study.

The ability to throw objects with speed and accuracy requires a constellation of anatomical features that evolved over time and first came together around 2 million years ago in the early human species *Homo erectus*, researchers reported in June in the journal *Nature*.

The timing, they write, coincides with archaeological evidence of early hunting activity.

The study is the first to trace the origins of powerful throwing and to propose a link to the dawn of hunting, a development that sparked a seismic shift in human history, says lead researcher Neil Roach, a postdoctoral scientist at GW's Center for the Advanced Study of Hominid Paleobiology.

"Humans are amazingly good throwers," Dr. Roach says. By comparison, the strong and athletic chimpanzee—man's closest living relative—throws at a speed about one-third that of a 12-year-old boy, he says. The difference, the researchers write, is in evolutionary changes to the shoulder, arm, and torso that enable human shoulders to gather and release energy like a slingshot.

To identify the mechanics involved, the research team—which included scientists from Harvard University, where Dr. Roach conducted the research as a doctoral student, and the National Centre for Biological Sciences, in India—analyzed the throwing motions of 20 males, most of whom were college baseball players.

Using a 3-D motion capture system, like those used to make video games and animated movies, the researchers recorded movements as participants threw baseballs at a target, then again while wearing a brace designed to limit their motion to mimic that of human ancestors.

"What we discovered was that during the throwing phase, in which the arm is pulled backwards, humans are storing elastic energy by stretching the ligaments, tendons, and muscles that are crossing the shoulder," Dr. Roach says. Releasing that energy whips the arm forward, generating a high-velocity throw.

That ability would have been vital to hunting, an important development that was beginning to intensify around the same time the anatomy for powerful throwing came together in *Homo erectus*, Dr. Roach says.

"Hunting really changed who we are and the way that we, as organisms, interact with the world," he says. "The additional calories that meat and fat provided would have also allowed *Homo erectus* to grow larger bodies, bigger brains, and to have more babies—all of which helped make us who we are today."

But exactly what these ancestors were throwing 2 million years ago remains a question, and an area where the team is turning their attention.

Pointed stone projectiles date to only around half a million years ago, Dr. Roach says, and before then the only weapons available would have been rocks and sharpened wooden spears. The team now plans to study how effective these early projectiles would have been for hunting.

—Danny Freedman

Watch Dr. Roach explain the findings at go.gwu.edu/throwing

CYBERSECURITY

RUSH TO CREATE PROFESSION MAY SLOW EFFORTS

Target and Neiman Marcus customers, many of whom have been victims of large-scale financial data breaches in recent months, are among the latest to discover what Diana Burley has known for years: Serious cyberattacks are a fact of consumer life. Any effective response to that threat will require a large and qualified cybersecurity workforce, but efforts to hastily professionalize such a broad group—through certification and licensure, for example—may actually be a stumbling block, according to a new report.

"You cannot professionalize a field; you professionalize occupations within a field," says Dr. Burley, who co-led the National Research Council study and is an associate professor in GW's Graduate School of Education and Human Development. Cybersecurity occupations, however, can be hard to define.

Many of the jobs under cybersecurity's broad aegis vary based on context, or range across multiple disciplines. Cybersecurity workers might wear two or more hats, for instance as law enforcement or health care professionals. And knowledge within cybersecurity is evolving rapidly.

The field's knowledge base will by nature never be static, Dr. Burley says, but in order to begin to professionalize "it needs to be stable enough that we can identify core principles, in particular occupational categories."

She is careful to emphasize, though, that none of that is to suggest that cybersecurity professionalization is not needed—only that an oversimplified, blanket approach to the process would be detrimental. Professionalization is intended to address specific deficiencies within an occupation, and the remedies need to match the problems.

Dr. Burley recalls a meeting with congressional aides who emphasized increased educational standards. When she asked what problem they hoped these new standards would solve, a staffer replied: "Well, there aren't enough people going into the field."

The conversation was illustrative, Dr. Burley says, of the fundamental mismatch between problem and remedy that results from a panicked rush to professionalize.

"If you're not careful and thoughtful about [professionalization]," she says, "you will end up doing more harm to the development of this workforce than good." And that, as anyone whose credit card has been compromised online will agree, is something no one can afford.

—Ruth Steinhardt

AUTISM

FOR KIDS WITH ASD, A FOCUS ON ADULTHOOD

$2.5M gift will endow first director of initiative to study, navigate transition

When 2-year-old Dylan was diagnosed with autism spectrum disorder in 1996, his parents—GW Board of Trustees Chair Nelson Carbonell Jr., BS '85, and Michele Carbonell—began a hopeful but often frustrating journey, as they grappled with the question of how they would provide their son with a healthy and meaningful life.

It is an era that they refer to as "the Dark Ages."

Eighteen years later, the world is very different for parents of young children with autism, with more early childhood intervention programs, stronger policies, and a greater understanding of the disorder. But for young adults with autism the world remains a difficult place to navigate.

"We're still in the Dark Ages. Nobody has figured out how to create a world in which these young adults can live independently, have jobs, and have a real life," Mr.

CHARTICLE

IT HAPPENED: PIGS' FLU

When a new influenza virus emerges, the world is its oyster. Everywhere it goes, it finds people with little or no immunity. The result: a pandemic. In 1918–19, the Spanish flu killed 1 percent to 2 percent of the world's population. Other pandemics came in 1957–58 and in 1968–69. Since then public health experts have been biting their nails, waiting for the next flu.

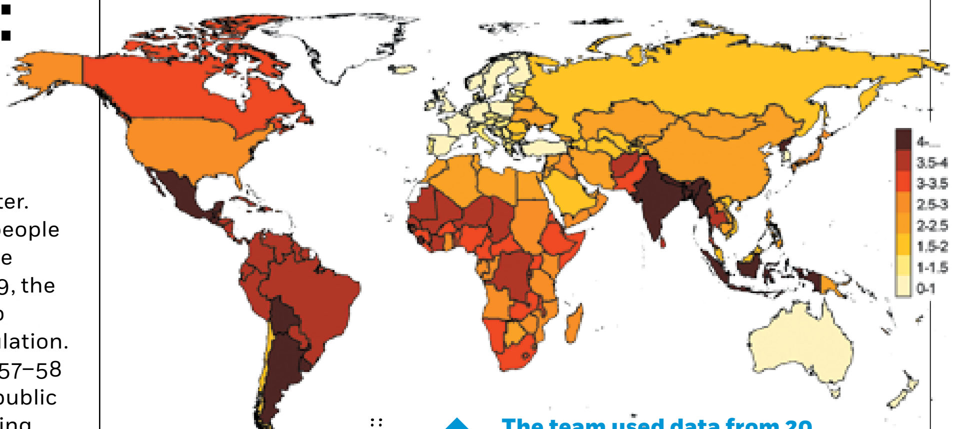
In 2009, it came: the H1N1 "swine flu." But it turned out to be a relatively mild pandemic, and critics complained that it had all been much ado about not much of a flu.

But counting flu deaths is hard. In a lot of the world, it's possible to be born and die without entering any official records. Countries that do collect detailed data may not be inclined to share it.

Lone Simonsen, a professor in GW's Department of Global Health, led a 26-nation research team for the World Health Organization that used statistical models to estimate the death toll of the 2009 pandemic. "This was a very big undertaking," she says. "It took us a lot of model development and negotiations."

The team found the number of deaths globally was much higher than the number confirmed by lab test—no surprise, given how few countries even have labs. The number was in the ballpark of a normal year, but the people who died were far younger, the team reported in November in the journal *PLoS Medicine*. This shows that the public health community was right to take the 2009 pandemic seriously, Dr. Simonsen says; it was bad, and it could have been worse.

—Helen Fields



The team used data from 20 nations to estimate flu mortality, and pulled factors like population density, gross national income, and doctors per capita to estimate the impact elsewhere (seen above as deaths per 100,000 people). Why Central and South America were hit so hard and Europe mostly escaped remains a mystery.

18,631

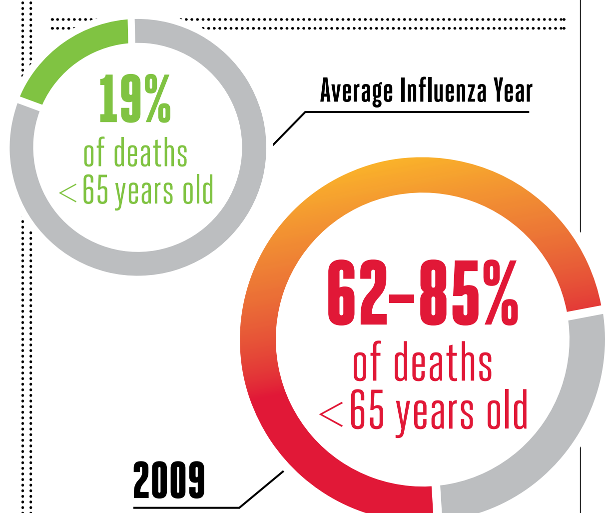
Lab-confirmed influenza deaths for the 2009 season, as reported by the World Health Organization

123,000–203,000

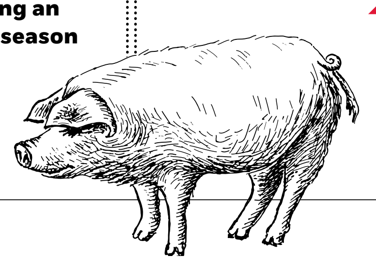
Respiratory deaths from influenza for the 2009 season, according to the study

148,000–249,000

Respiratory deaths during an average flu season



Pandemics hit young people hardest, possibly because they don't have antibodies left over from past pandemics.



MAP: SIMONSEN ET AL. (2013) PLOS MEDICINE / PIG: ©iSTOCK.COM/LENAALYONUSHKA

Carbonell says. "Now that our son is 20, we're facing similar challenges that we faced when Dylan was 2 years old. There aren't good programs, policies, or strategies for autistic adults and teens transitioning to adulthood."

Compelled by this reality, the Nelson A. and Michele Carbonell Family Foundation announced in April a gift of $2.5 million, which will provide an endowment for a professor who will serve as the inaugural director of GW's Autism and Neurodevelopmental Disorders Initiative.

"GW has done many things in this area, and we think that our gift will allow us to bring those efforts into focus to make it real and make it permanent," Mr. Carbonell says.

The interdisciplinary initiative has 86 affiliated faculty members—from five schools around the university—who are applying a multidisciplinary approach to research, policy, and treatment for individuals with autism and neurodevelopmental disorders.

The director will tie together these moving parts, making GW an integrated resource for people with autism and their families to obtain state-of-the-art assessments, interventions, medical treatments, support services, and opportunities to participate in research and clinical trials. The initiative also will help shape policy and programs that will streamline and make affordable the necessary services for people with these disorders.

"These young adults—they are the first wave of the autism epidemic," says Ms. Carbonell, chair of the national capital area chapter of Autism Speaks, an advocacy and science-funding organization. "We need to do better by them. And we don't have time to waste."

—Lauren Ingeno

WWW For more on the AND Initiative and the work of GW researchers, visit **go.gwu.edu/andinitiative.**

CURRICULUM

'I AM MALALA' COMES TO CLASSROOMS

Sixteen-year-old Malala Yousafzai has become a symbol of peace and hope to millions around the world. The youngest-ever Nobel Peace Prize nominee has campaigned since the age of 11 for the education rights of girls and was shot in the head by the Taliban in 2012 for making her voice heard.

Now GW's Global Women's Institute is bringing her story into the classroom, hoping it will deepen students' understanding of women's rights issues and inspire activism.

As the educational partner of the Malala Fund—a nonprofit that works to ensure girls' access to education—GWI-affiliated faculty members will work with publisher Little, Brown and Co. to develop a university-level curriculum to accompany Ms. Yousafzai's 2013 memoir, *I Am Malala*.

The curriculum will focus on themes such as the importance of a woman's voice, how education empowers women, global feminism, and political extremism, and will encourage students to take action through service learning and advocacy.

"Malala's courageous campaign for girls' education is an inspiration to all," says GWI Director Mary Ellsberg. "We are honored to serve as the Malala Fund's educational partner and to work with Little, Brown and Co. to develop a curriculum that will not only educate students but spark the very activism Malala stands for."

The curriculum will be made available to faculty members and students around the world at no cost beginning in mid-2014. At GW, it will be created by an interdisciplinary group from the Columbian College of Arts and Sciences, the Elliott School of International Affairs, the Graduate School of Education and Human Development, and the University Writing Program.

"We'd like to encourage college students and eventually high school students to get involved, to facilitate dialogues among various groups, and to influence public opinion," says Michele Clark, an adjunct professor in international affairs who is among those working on the project.

At the announcement of the *I am Malala* curriculum development, in October, students and faculty members gathered in support of activist Malala Yousafzai, who was shot by the Taliban.

JESSICA MCCONNELL BURT

NEW FACES

LISA BOWLEG

PROFESSOR OF PSYCHOLOGY

AREA OF RESEARCH: HIV prevention among black men, in particular heterosexuals, and the design of interventions that take into account the intersection of identities, such as race, class, and gender—for example, being Latina and a woman.

BACKGROUND: The three-time GW alumna—including her PhD in 1997—returned to the university in 2013 from Drexel University, bringing with her a pair of new, five-year grants from the National Institute of Mental Health.

CURRENT PROJECTS: Heterosexual black men have been "surprisingly absent" from much of the HIV research and interventions, she says, despite accounting for the majority of cases among men due to heterosexual transmission. To help fill that void, Dr. Bowleg is co-leading, with a colleague at the University of California, San Diego, a study that tests whether embedding HIV prevention into case management services for other needs—in this case, heterosexual black men seeking help with unstable housing or unemployment—will result in less risky behaviors than those of a control group.

A second study led by Dr. Bowleg is aimed at understanding the role of neighborhoods in HIV risk. Public health experts "can tell you so much about your health outcomes based on where you live," she says, like issues involving nutrition and obesity. "Might it be the same effect for HIV, particularly since in the U.S. HIV is densely concentrated in predominantly black and Latino low-income networks and neighborhoods?"

In D.C., where the HIV prevalence, at last count, in 2011, was 2.4 percent in general and 5.4 percent among black men—more than five times the U.N.'s 1 percent threshold for a "generalized epidemic"—stones can hardly be left unturned.

She's now in the process of trying to reveal stressors and strengths for neighborhoods across D.C. by gathering and mapping neighborhood block-level data, such as crime, homeownership, and retail presence, and conducting interviews with black men in D.C.

"The issues are so much bigger than just HIV when you talk about health disparities in black communities," Dr. Bowleg says. "We know this. It's hypertension, diabetes—it's all that stuff. HIV becomes just one other thing. So understanding it in a new way, beyond individual behavior, has lots of opportunities for intervention."

—Danny Freedman

IMMIGRATION

FLEXIBILITY AFFECTS PATH TO CITIZENSHIP

For the thousands of non-U.S. citizens who spend time living in government-sponsored housing, the flexibility they are given in choosing a home can be an important factor in eventually attaining citizenship, according to researchers.

"All other things being equal, if one [immigrant] is in a voucher program and the other is in a housing project, the voucher program recipient is more likely to naturalize," says study lead John Carruthers, program director of the Sustainable Urban Planning Program at GW's College of Professional Studies. In that sense, housing choice has "a statistically significant impact on the likelihood of your becoming a citizen," he says.

The study, published last year in the *Journal of Regional Science*, used U.S. Department of Housing and Urban Development data from 2007 to 2009. The team—which also included political scientist Natasha Duncan of Mercyhurst University and statistician Brigitte S. Waldorf of Purdue University—found that voucher program participants were up to 7 percent more likely to naturalize than immigrants given space in housing projects.

"These numbers seem small but they are substantive, given the limited number of people who transition to citizenship," Dr. Carruthers says.

The key is flexibility, he says. Voucher program enrollees may choose to live closer to jobs or schools or family, rather than being tethered to the locations of

JESSICA MCCONNELL BURT

a housing project, helping them achieve their goals.

"Neoclassical economics teaches us that individual welfare, and in turn societal welfare, is maximized when people are able to make their own choices," says Dr. Carruthers.

The findings, he says, may be counterintuitive to some. "Many people have a tendency to want to give in-kind transfers [when thinking about aid]," he says. "'You want a house? OK, here's a house, and you live where I want you to live.' That's a very natural reaction to seeing your tax dollars spent on public aid. But if you give flexible cash-like aid, instead of in-kind transfers, you enable people to make their own decisions."

—Ruth Steinhardt

FLUID DYNAMICS

FLYING SNAKES SOAR WITH AID FROM VORTICES

They slither, they sneak, they hiss, they ... fly?

Despite their wingless bodies, some snake species in the lowland tropical forests of Southeast and South Asia can glide—the animal kingdom's only gliders to manage without appendages. They push off from tree branches, rotating their ribs to flatten their bodies and making side-to-side movements, soaring as far as 100 feet. One species is even known to turn in midair.

So how do they do it?

Lorena Barba, an associate professor of mechanical and aerospace engineering, led a team that built a two-dimensional computer model of a cross section of a snake in order to explore the fluid dynamics at work.

The study, conducted at Boston University and published online in March in the journal *Physics of Fluids*, confirms the findings of earlier physical experiments by team member Jake Socha, a biomechanics professor at Virginia Tech. But while that research suggested the snakes' bodies generate quite a bit of lift, the computational study allowed the team to explore the forces behind it.

What they found was that small vortices, or whirlwinds, generated around the snake offer a boost in the form of upward suction. Next the team hopes to construct a 3-D model to investigate why snakes wiggle in the air.

"It's not wild to think that our understanding of the fluid mechanics of this particular shape could lead us to, for example, design a different type of airflow that is ideal for energy harvesting or a wind turbine—or who knows," Dr. Barba says. "You find applications in unexpected places."

—Lauren Ingeno

CHEMISTRY

A FASTER FIGHT AGAINST TERROR AGENTS

DARPA award seeks to reduce years-long process down to one month

Knowing one's enemy is a tenet of war, but in the fight against chemical and biological weapons it can be exceedingly arduous and time-consuming. Now a team led by a George Washington University researcher is working to vastly improve the process under a grant that will provide up to $14.6 million over five years.

The grant, from the military's Defense Advanced Research Projects Agency, tasks the researchers with reducing to 30 days a process that can sometimes take years or even decades.

"Clearly, this is a very large challenge, and it's easy to understand why it's important to overcome," says lead researcher Akos Vertes, a GW chemistry professor who will be collaborating

***Chrysopelea ornata*, one species of flying snake**

with GE Global Research, Protea Biosciences Inc., and SRI International.

"Discovering the cause behind a biological or chemical threat can provide information that not only counteracts the threat," Dr. Vertes says, "but also provides important information for pharmaceutical companies developing drugs that may be unrelated to the threat."

Biological threats, like anthrax, derive from bacteria, viruses, toxins, or fungi. Chemical threats include substances that work to interfere with the nervous system or cause asphyxiation. Both have the potential to cause rapid and widespread injury or death.

To determine how a biological or chemical threat disrupts the functions of life, researchers have to take a holistic view of the threat and the system in which it operates. Dr. Vertes and his team will use a variety of scientific disciplines—including transcriptomics, proteomics, metabolomics, and bioinformatics—to analyze the effects of toxic agents on genes, proteins, and cellular functions. By combining the data, the researchers believe the effects of a biological or chemical threat can be more easily determined.

SUSTAINABILITY

FORMER USDA OFFICIAL TO LEAD INSTITUTE

Kathleen A. Merrigan, former deputy secretary of the U.S. Department of Agriculture, has been named the first executive director of GW's Sustainability Institute.

As leader of GW's sustainability initiatives, Dr. Merrigan will be responsible for launching and nurturing a Sustainability Institute that advances the university's prominence in multidisciplinary education, research, and outreach.

"Kathleen Merrigan has exactly the combination of deep experience, professional stature, and energetic commitment we need to launch this important effort," GW President Steven Knapp says. "Under her leadership, the Sustainability Institute will enable us to develop a full academic complement to the sustainability work we are actively pursuing across the university's operations."

Named one of *Time* magazine's "Most Influential People in the World" in 2010, Dr. Merrigan was nominated in 2009 by President Barack Obama to serve as USDA deputy secretary. During her four-year tenure she oversaw the agency's daily operations. She also created and led the "Know Your Farmer, Know Your Food" initiative to support local food systems; served as a key architect of first lady Michelle Obama's "Let's Move!" campaign; and represented the United States before the United Nations Commission on Sustainable Development.

Before joining the USDA, Dr. Merrigan served for nearly a decade as a faculty member and director of Tufts University's Agriculture, Food and Environment Program.

Sustainability is one of GW's core strategic initiatives and an area of wide-ranging research and academic expertise. The university offers more than 250 courses on topics related to sustainability and 40 undergraduate, graduate, and postgraduate programs in related fields, including an 18-credit minor in sustainability.

Kathleen Merrigan

JESSICA MCCONNELL BURT

INT'L AFFAIRS

HANGING IN THE BALANCE

U.S. policy shift in Asia-Pacific walks tightrope of relationships in region

A recent U.S. policy shift toward greater involvement in the Asia-Pacific area has been embraced by many of the region's nations, but its success hinges on an exceedingly delicate, regionwide balancing act, according to a new analysis.

"A happy ending is possible but not guaranteed," researchers from the Elliott School of International Affairs conclude in an August report from GW's Sigur Center for Asian Studies.

When President Obama took office, he initially followed the precedent of both the Clinton and Bush administrations in their approach to the region, says lead author Robert G. Sutter, a professor of practice in the Elliott School. "The bottom line was: manage that relationship with China well, and you didn't do things with neighbors that would be upsetting to China," he says.

The fall of 2011, however, marked the start of a recalibration of U.S. engagement in the region—an evolving mix of military, economic, and diplomatic initiatives—that has

Dancers from the Dana Tai Soon Burgess Dance Company perform "Homage" in November at the Smithsonian's National Portrait Gallery. Mr. Burgess, MFA '94, chair of GW's Department of Theatre and Dance, is serving as the Smithsonian's first-ever resident choreographer during the Portrait Gallery's first American dance exhibit, "Dancing the Dream," for which he created "Homage" and another piece, "Confluence," which debuted in April. As part of their residency, Mr. Burgess and his dancers held public rehearsals inside the exhibition leading up to the debut performance of each piece.

WILLIAM ATKINS

caused friction with China, the regional power most suspicious of U.S. aims.

For other nations the shift serves as a counterbalance to an "increasingly assertive China," the authors write, and offers reassurance that Washington—rather than being exhausted by wars in Iraq and Afghanistan—can be a source of stability and growth in the region.

Michael E. Brown, dean of the Elliott School and one of the report's authors, says the policy pivot is part of a "grand strategy for the United States in geostrategic terms, which makes this an issue of considerable importance."

The shift has drawn support in Congress and in the region, even if muted, as many nations walk a tightrope of maintaining good ties with both the United States and China. Critics view the policy as antagonizing China, unsustainable, or as something the president isn't really committed to, Dr. Sutter says.

A summit last June between President Obama and Chinese President Xi Jinping appeared "successful in meeting its limited aims," the authors write, but it is "much too early to tell if the summit represents a turning point in a relationship that has growing structural tensions."
—Menachem Wecker

WWW **View the full report at go.gwu.edu/rebalance.**

PUBLIC HEALTH

RECORD GIFTS TO TRANSFORM PUBLIC HEALTH

$80M will fuel research, scholarships and establish center for prevention

It may be one of GW's youngest schools, but with a brand-new name, a new building to call home, and the acquisition of the largest monetary gift in university history, the Milken Institute School of Public Health is a force to be reckoned with.

In March the university announced three gifts totaling $80 million that will advance public health research, fund scholarships, and create a center for prevention and wellness.

The collaborative philanthropy includes $40 million from the Milken Institute to support new and ongoing research and scholarships; $30 million from the Sumner M. Redstone Charitable Foundation to develop and advance strategies to expand wellness and the prevention of disease; and $10 million from the Milken Family Foundation to support the Milken Institute SPH dean's office, including a newly created public health scholarship program.

In honor of the gifts, GW's Board of Trustees approved the renaming of the public health school and the establishment of the Sumner M. Redstone Global Center for Prevention and Wellness. The center will be led by William H. Dietz, an expert consultant on obesity, nutrition, and physical fitness who previously served for 15 years as the director of the Division of Nutrition, Physical Activity and Obesity at the federal Centers for Disease Control and Prevention.

"For decades, Mike Milken and Sumner Redstone have exemplified philanthropy of the most visionary and powerful kind," says GW President Steven Knapp. "These new resources will greatly enhance our university's capacity to address global health challenges with life-altering solutions."

SPACE

THE LIGHT STUFF

1-inch thrusters for small satellites prepare for space

Tiny thrusters built by GW researchers soon may be making their first voyages to space, where they will be used to propel pint-size satellites.

Following a successful round of tests last summer at NASA's Ames Research Center, in California, the roughly 1-inch-long thrusters have entered the next phase of development toward a NASA mission, says Michael Keidar, a professor of mechanical and aerospace engineering.

"The main objective right now is further miniaturization and maturing of the technology," he says.

Separately, Dr. Keidar's lab is collaborating with the U.S. Naval Academy's Small Satellite Program to use the thrusters on a test flight anticipated to be launched in early 2015, Dr. Keidar says.

In both cases the thrusters are being tested on a diminutive class of satellites known as "cubesats," which typically measure just under 4 inches per side—about the size of a tissue box. As electronics become smaller and more powerful, these types of tiny flyers are opening the door to space-based science and exploration at a fraction of the cost of a full-size satellite.

For NASA, the thrusters would be used on a future generation of the PhoneSat series: cubesats, weighing just 2 pounds, that are powered primarily by components from an off-the-shelf Google smartphone.

The first, $3,500 PhoneSats were launched last April—the lowest-cost satellites ever flown, according to NASA—and sent back data, including photographs. Later iterations are testing even more functionality, like reaction wheels to turn the cubesat. The addition of thrusters, according to NASA, could widen the possibilities for small satellites to include interplanetary missions and Earth observations.

To propel a cubesat, thrusters need to work around the significant constraints of size, weight, and power. They "don't have the luxury of carrying gas" for fuel, as a larger spacecraft would, Dr. Keidar says.

The thrusters designed in his lab carry titanium, which is converted into gas-like plasma to provide propulsion, and each would run on about 10 percent of the cubesat's power supply.

The thrusters also are capable of firing constantly—a unique ability for thrusters of this size, Dr. Keidar says—enabling a satellite to reach and maintain a desired orbit for at least a year, perhaps much longer.

—Danny Freedman

NASA's diminutive PhoneSat 1.0 sits beside a coffee mug.

NASA AMES RESEARCH CENTER

FACILITIES

SCIENCE AND ENGINEERING HALL 'TOPS OUT'

Construction of GW's Science and Engineering Hall in December reached its "topping out," a milestone marking the completion of the topmost point of the building's concrete structure.

The building, which the university broke ground on in 2011, will be a hub of research and teaching on the Foggy Bottom Campus. With eight floors above ground and six below, including four floors of parking, the building will offer 290,000 square feet for classrooms, labs, and specialized research facilities, including a three-story-tall "high bay" facility and a nanofabrication suite, among other amenities.

"This is the milestone we've all been waiting for," President Steven Knapp said at a celebration. "We're just a little over a year away from opening the building and bringing our students and faculty into what is going to be an extraordinary new part of this university."

The building "is sometimes referred to as a catalyst, but that is not entirely accurate," said School of Engineering and Applied Science Dean David Dolling. "A catalyst simply speeds things up that were going to happen anyway, whereas this center is an enabler, because it has enabled us and will continue to enable us to do what we could not do before and accomplish more as a university." *—Brittney Dunkins*

To see a video from the "topping out" celebration, visit go.gwu.edu/toppingout.

NICHOLAS GINGOLD

IN BRIEF

SOLAR TEAM MAKES TOP 10 FINISH

A team of students and faculty members from GW, American, and Catholic universities placed seventh in the U.S. Department of Energy's Solar Decathlon in October. The team designed and built a 700-square-foot, solar-powered house and surrounding garden, called Harvest Home, which will be donated to a veteran.

INTERNATIONAL SECURITY WORK AWARDED $2.4M

The Carnegie Corp. of New York awarded a two-year, $2.4 million grant to the Elliott School of International Affairs to support the Project on Middle East Political Science, the Program on New Approaches to Research and Security in Eurasia, and two programs focused on nuclear policy and security.

$1.8M FOR CENTER TO IMPROVE HEALTH CARE DELIVERY

The federal Health Resources and Services Administration has awarded Associate Professor of Health Policy Patricia Pittman a $1.8 million grant to establish a center that will study health care workforce challenges that play a role in access to care, quality of care, and its cost. Those include the ability of health care workers to meet future demands and ways to improve efficiency and effectiveness.

ENTREPRENEURSHIP PROGRAM IN TOP 25

The GW School of Business in September was named one of the nation's top 25 graduate entrepreneurship programs by the Princeton Review and *Entrepreneur* magazine. Schools were evaluated on factors that included commitment to entrepreneurship inside and outside the classroom; the percentage of faculty, students, and alumni involved in entrepreneurial endeavors; and the number and reach of their mentorship programs.

RESEARCH NEWS

Q&A

SMPA professor Jason Osder's new film examines the day in 1985 that "the unthinkable" became reality.

FILM

SEEING THROUGH THE BLAZE

In 1985, Philadelphia police dropped explosives on a house filled with members of the extremist African-American MOVE organization after years of conflict between the two groups. A resulting fire, which killed 11 people, five of them children, and destroyed 61 homes, was allowed to burn for more than an hour despite firefighters standing by.

School of Media and Public Affairs professor and Philadelphia native Jason Osder researched this catastrophe for nearly a decade for his documentary *Let the Fire Burn*. Since its release last year the film has appeared in dozens of festivals, including the Tribeca Film Festival, where it took "Best Editing in a Documentary Feature" and a special jury mention in the "Best New Documentary Director" category. The film, available on iTunes, Netflix, and elsewhere, was released on DVD in March. —CAITLIN CARROLL

Why did you decide to make the film using only archival materials—no interviews or narration?

I never wanted to interview everyone who had anything to say about this. I wanted to find a handful of people who were really participants. I was doing fairly well with that up until I brought the editor on, and when we looked at all the materials we realized that the interviews had certain liabilities and the archival materials had certain strengths. We saw a creative opportunity, and we thought the result would really keep you in the moment—the past in present tense.

If it worked, it would be something special. And if it didn't work, it would sort of fall on its face. It wouldn't really be a film.

OSDER: JESSICA MCCONNELL BURT / INSET: ZEITGEIST FILMS

The 1985 explosions and resulting fire killed 11 people—five of them children—and destroyed 61 homes.

COURTESY ZEITGEIST FILMS

What do your research and storytelling illuminate about the incident?
In a lot of work like this there is a belief that excavating the material is worthwhile in and of itself. If there is this literal or figurative dark corner that hasn't been explored, we ought to shine a light in there and figure out what knowledge lurks there.

I think it is sort of cursory to say that we were solving a mystery of who is responsible for this. That's not primarily the type of mystery I was trying to solve. I think it's more of a moral mystery. You say five children and six adults die in a fire set by police that they chose not to fight: It's unthinkable. How could that have taken place? I think the incident provokes that question in stark relief. How does the unthinkable come to happen?

What I hope to reveal through the film is that once people are dehumanized, once we as individuals look at another individual and see something besides a fellow human being—any label, really—that's how the unthinkable comes to pass. Whatever the label is—black or MOVE or gay or straight or Muslim or whatever—if you see that ahead of a person as sort of a shield in front of a person, that's the first step to the unthinkable coming to be. That's how you get to "let's kill the kids, too" or "let's let them burn."

Why don't you think this event is well-known in American history?
I think it's a very, very complex story, and I think that is an impediment to becoming part of the public knowledge. Overlay with that the racial nature of the incident, and I think for a long time, especially on television, the combination of complexity and race had not been covered well.

You faced a lot of issues with accessing the archival footage used in the film. How did you get over those barriers?
The thing with accessing the footage really is at the heart of the difference between making a film completely independently and partnering with an institution. I had been working on the film before I joined the faculty, but I was really pretty stuck. When I joined the faculty I got access to a number of things—some more tangible than others. We have this strong Office of General Counsel, and they went to work for me. One way to look at how they helped me crack the access issue is the combination of the letterhead and the lawyers.

Have any reactions to the film surprised you?
I always thought that I was making a provocative film that people would want to discuss, but I felt that there would be a certain amount—and this may still happen in Philadelphia—of heat in those discussions. I felt like people would want to argue about the film, about who was right and who was wrong. And they do want to talk, but the tone is not combative. That has been the big surprise for me.

You're beginning work on a new project with fellow School of Media and Public Affairs professor William Youmans. What can you tell us about that?
We're at the very early stages of researching. It starts with an assassination in 1985 in southern California of an Arab-American leader. There are allegations that this was at the hands of a Zionist organization. And in a lot of ways this is sort of a mythic story in the Arab-American community. And so the idea is to explore this assassination-slash-murder-mystery, but also explore more deeply the phenomena of what it means if one community in America has a whole mythic story that they tell and the rest of us are unaware of it.

For more on the film and to view the trailer, visit www.lettheFireburn.com.

RESEARCH NEWS

CROSSROADS

Atop a workbench in Dr. Plesniak's lab, a set of drawers contains casting molds and small, rubber-like synthetic vocal cords and polyps, as well as the materials used to refine them. By adding layers and materials like cotton and wool, the lab team strives to better imitate the different tissues of the vocal cords.

FLUID DYNAMICS

THE GIFT OF GAB

A mechanical engineer, a speech pathologist, and a throat surgeon team up to better treat disorders of the vocal cords

–By Jennifer Walker

In GW's Biofluid Dynamics Laboratory, "The Moose"—an autonomous model of the human vocal tract, from lungs to mouth—emits a low, persistent growl like the antlered animal's distinctive mating call. Air rushes in from a circular chamber representing the lungs, passes through a plastic tube stand-in for the trachea, then across a synthetic larynx, or voice box. There, a pair of life-size vocal cords fashioned from silicone—about the size of a penny—stretch and vibrate in the gust of air, generating a voice. A camera at the end captures high-speed images of the process.

The machine, in the lab of Mechanical and Aerospace Engineering Department Chair Michael Plesniak, may soon help treat common vocal disorders—the voice, after all, is as much about communicating and identity and melody and harmony as it is about aerodynamics and structure. While engineers have mined for decades the mechanics of vocalization, "the complexity inherent to the human voice continues to confound," Dr. Plesniak and his colleagues write in a recent review paper.

For Dr. Plesniak and five current and past postdoctoral and student researchers, this latest model—in which the vocal cords respond on their own to produce sound from the rush of air—is "the holy grail," the one that most closely resembles the human vocal tract. Even still, many parts can be manipulated for studies and refinements, from the angle of the vocal cords to the materials used to make them.

To accurately re-create the process of sound production, Dr. Plesniak is collaborating with Adrienne Hancock, an assistant professor in the Department of Speech and Hearing Sciences, and Steven Bielamowicz, a professor of surgery and chief of the otolaryngology division at the School of Medicine and Health Sciences, to compare measurements taken in the lab with data and videos collected from clients and patients.

Once a physical model is perfected, computational models can be created that clinicians like Dr. Bielamowicz can use for surgical planning.

JESSICA MCCONNELL BURT

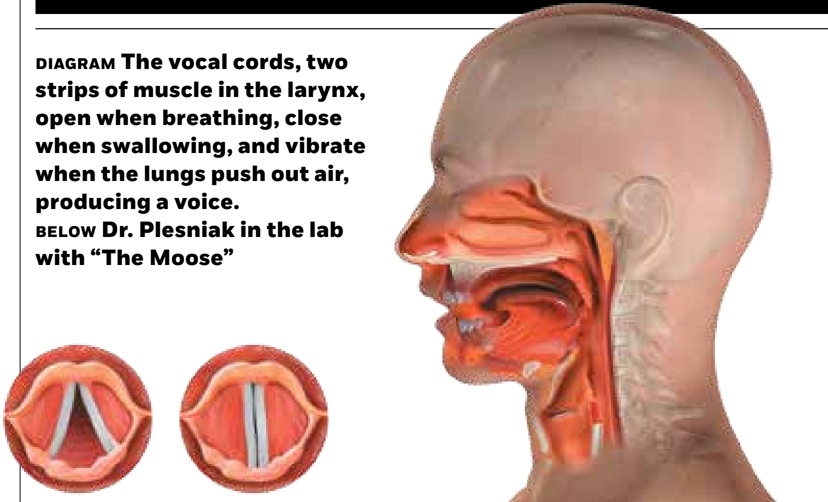


DIAGRAM The vocal cords, two strips of muscle in the larynx, open when breathing, close when swallowing, and vibrate when the lungs push out air, producing a voice.
BELOW Dr. Plesniak in the lab with "The Moose"

The impact could be wide reaching: Thirty percent of people will suffer from a voice disorder in their lifetimes; for those who use their voices often, such as teachers and singers, the number leaps to 60 percent. "There's a huge economic impact with treatments and lost work," Dr. Plesniak says. Caused by abnormalities on the vocal cords, such as a polyp or a nodule—bumpy masses that can sprout from voice overuse—voice disorders can cause breathy, hoarse, or nasal voices, or pitch that is too high or too low.

Studying how these conditions affect phonation is part of his research, including a project funded by the National Science Foundation. But even understanding normal speech production is difficult. When the vocal cords vibrate to produce sound, the maximum space between them is about one millimeter—not a whole lot of room for detailed analyses of the forces at work.

Earlier models built by Dr. Plesniak had scaled up the anatomy to provide a better look and utilized a wind tunnel on the Virginia Science and Technology Campus to create unsteady airflow; another type used programmable motors to mimic the movement of vocal cords.

Both types had limitations. Even the current, self-oscillating model gets constant adjustments, a process that is still to some extent trial and error. A workstation in the lab is anchored by a bin of nearly 40 drawers filled with casting molds, an array of sometimes humble materials, like cotton, and various iterations of the small, rubbery vocal cord models. The latest version, likely not the last, is a two-layer silicone model mixed with wool for a more realistic oscillation.

Other parts of the machine are manipulated based on data received from Dr. Hancock, who is researching how aging affects the voice. In her lab, men ages 20 to 40 and 60 to 80 cover their noses and mouths tightly with a mesh-screened Rothenberg mask, similar to a surgical mask, then say "Ahhh."

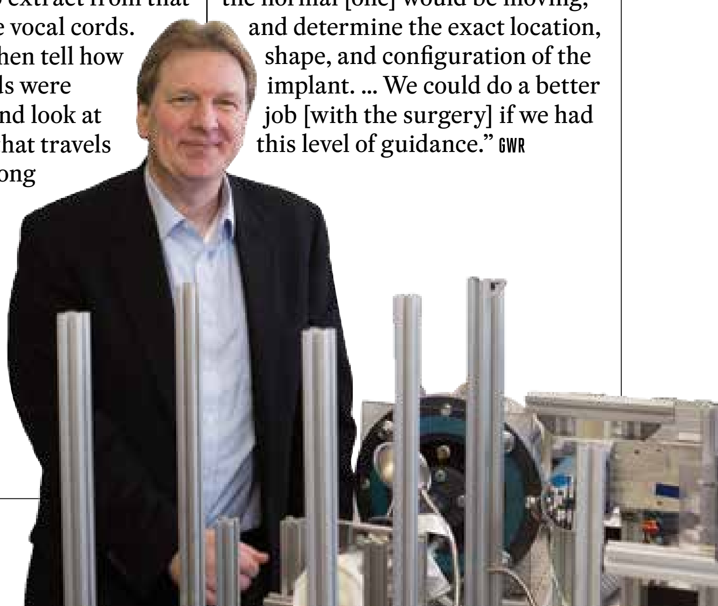
The mask captures the signal of the person's voice, and then software is used to extract from that the signal from the vocal cords. Dr. Hancock can then tell how long the vocal cords were open and closed, and look at the amount of air that travels through them, among other parameters.

In his self-oscillating model, Dr. Plesniak can re-create this scene by placing the vocal tract and other parts in positions that correspond to those of study participants making the same sound. He attaches a Rothenberg mask to the tract connecting the synthetic vocal cords to the machine's "mouth," takes the same measurements, and compares them with Dr. Hancock's data, a collaboration that is funded by a seed grant from GW's Institute for Biomedical Engineering.

Dr. Bielamowicz also sends data in the form of high-speed videos of vocal cord motion, taken from his patients at GW's Voice Treatment Center, which Dr. Plesniak can slow down and compare with the motion he sees in his models.

Eventually Dr. Plesniak and his colleagues intend to use the physical models to build computational ones, which Dr. Bielamowicz would use for surgical planning, mainly for patients with vocal cord paralysis. The condition usually affects one vocal cord, preventing it from vibrating and causing a weak or breathy voice. Fitting a custom implant to the side of the paralyzed vocal cord is the most common surgery, but doing so "requires a significant amount of clinical educated guessing," Dr. Bielamowicz says.

Using the computational model, Dr. Bielamowicz could create patient-specific comparisons of the paralyzed vocal cord and the normal one. "Then we can see how the normal [one] would be moving, and determine the exact location, shape, and configuration of the implant. ... We could do a better job [with the surgery] if we had this level of guidance." GWR



TOP: CLAUS LUNAU / SCIENCE SOURCE / BOTTOM: JESSICA MCCONNELL BURT

SHELF LIFE

MEDICINE

THE RHYTHM AND BLUES

Dick Cheney and his cardiologist of 15 years, GW's Jonathan Reiner, discuss their interactions and the advances in the treatment of heart disease over the past 35 years

Unlike most politicians who have spent considerable time at GW, former Vice President Dick Cheney is not an alumnus, a faculty member, or a frequent lecturer on campus. The Lincoln, Neb., native came to GW on several occasions for reasons much more grave: treatments at GW Hospital for cardiovascular disease.

"*If this is dying,* I remember thinking, *it's not all that bad,*" he writes in the prologue to his new book, *Heart: An American Medical Odyssey* (Scribner, 2013), co-written with Jonathan Reiner, his cardiologist and the director of GW Hospital's Cardiac Catheterization Lab.

The book alternates between memoir-style and historical vignettes in Mr. Cheney's and Dr. Reiner's voices, and although the latter's sections are heavy on medical terminology, the prose is whimsical and accessible. A defibrillator sits on a "fire-engine-red" cabinet, for example; latex gloves make a "characteristic thwack," and a catheterization lab is a "multimillion-dollar cathedral to the latest technology."

Elsewhere, Dr. Reiner waxes philosophical: "Medical school ... teaches plenty of science but very little of the art of being a doctor"; and, he writes, "I know that heart transplantation is fundamentally an elegant surgical procedure ... but for me, like the birth of a child, the awakening of a heart in its new host is a moment filled with divine grace." Other passages discuss everything from an autopsy Leonardo da Vinci performed in Florence in 1507 to five pints of blood that were drained from George Washington's arm on Dec. 14, 1799, before he died later that evening.

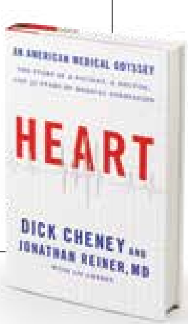
Mr. Cheney's 35-year struggle with heart disease is a fascinating and highly personal story in its own right, and when it is interwoven with the observations and recollections of Dr. Reiner the narrative takes on further complexity and context. Both Mr. Cheney and Dr. Reiner have the humility and insight to recognize that their already compelling stories become even more intriguing when supplemented with political and medical history. *Heart* is about not only the heart of one man—albeit a very famous and powerful man—but all hearts.

Nowhere is the wonder of that organ more apparent than in Dr. Reiner's observation that "Over an eighty-year life, a human heart beats, uninterrupted, 2.5 billion times, an astonishing example of physical durability seldom, and maybe never, replicated by even the most sophisticated human engineering. An automobile motor, for comparison, will make less than 500 million revolutions if you're lucky enough to keep it running for 100,000 miles."

Other perks of reading the book? Learning Mr. Cheney's pseudonym when he was admitted to GW Hospital in November 2000 and seeing a photograph of him holding a tabloid claiming he had become a robot.

—*Menachem Wecker*

***Heart: An American Medical Odyssey* (Scribner, 2013)**
Dick Cheney and Jonathan Reiner



REINER: JESSICA MCCONNELL BURT / HEART, THE EVIL NECESSITY, THE GAMBLE, IRAQ IN WARTIME: WILLIAM ATKINS / THE NEW VISUAL NEUROSCIENCES: JESSICA MCCONNELL BURT

The New Visual Neurosciences (MIT Press, 2013)

John S. Werner and Leo M. Chalupa

Light streams in and is focused, filtered, and then collected by more than a hundred million cones and rods, which ship it to central processing along a million high-speed cables. That's the first instant of seeing these words. Then there's the recognition of shapes, patterns, color, texture, and meaning. "And it's all effortless," says neuroscientist and GW Vice President for Research Leo Chalupa. It's a process that Dr. Chalupa, a professor in the Department of Pharmacology and Physiology, explores in infinite detail in this book co-edited with neuroscientist John S. Werner, of the University of California, Davis. The compendium, penned by top scholars in the field, is a follow-up to the editors' 2004 edition. With coverage of new topics, like optogenetics—the engineering of brain cells that can be controlled by light—the book sets out to remap an expanding landscape and offers a study of machinery still unrivaled by the best efforts of mankind. *—Danny Freedman*

The Evil Necessity: British Naval Impressment in the Eighteenth-Century Atlantic World (University of Virginia Press, 2013)

Denver Brunsman

Students of world history know well that the sun never sets on the British Empire, but they might not know about the sailors forced to man the ships that made up the crown's unparalleled fleet. In wartime, Britain "impressed," or forced, its subjects to join its navy. "Impressment was more than a stopgap measure to keep the Royal Navy afloat," writes Denver Brunsman, an assistant professor of history at GW. "It was a fundamental component of Britain's early imperial success." Instead of targeting criminals and the lower classes, the Royal Navy conscripted men who were skilled sailors and who typically stood to make less in their new, involuntary naval employment than in their old day jobs. And therein lay what Dr. Brunsman calls the "impressment paradox"; given how much sailors and their local communities fought the so-called press gangs that came to enlist conscripts, it's surprising that impressment was so successful. *—M.W.*

The Gamble: Choice and Chance in the 2012 Presidential Election (Princeton University Press, 2013)

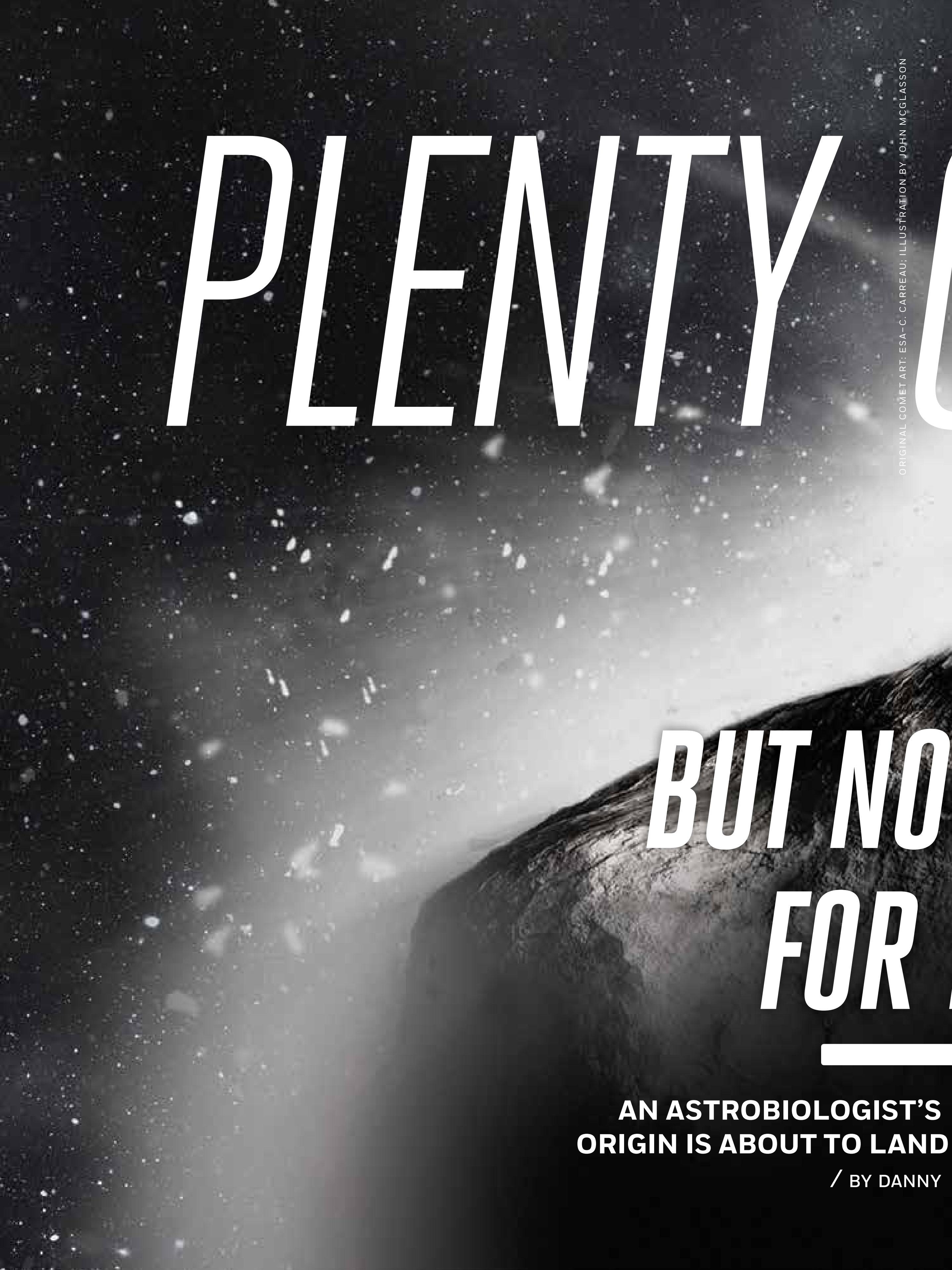
John Sides and Lynn Vavreck

The term "game changer," which was wielded early and often in the analysis leading up to and during the 2012 presidential election, was largely misapplied to "blips that failed to transform the race," write John Sides, an associate professor of political science at GW, and Lynn Vavreck, a professor at the University of California, Los Angeles. U.S. presidential elections, they write, are "rarely decided by a single moment that changes everything." Instead factors like the economy tend to have a much greater impact. This book adopts a data-driven, *Moneyball* approach to the question of what propelled President Barack Obama to a second term. "Our answer turns more on the advantages incumbent presidents have even in slowly growing economies and less on television advertising or field organizations," the authors write. That's not to say that the $2.3 billion spent was entirely wasted, but that the spending balanced out. *—M.W.*

Iraq in Wartime: Soldiering, Martyrdom, and Remembrance (Cambridge University Press, 2013)

Dina Rizk Khoury

Iraqis who saw invading U.S. and coalition forces in 2003 must have experienced one of the worst kinds of déjà vu. "War had become the norm rather than the exception," writes Dina Rizk Khoury, an associate professor of history and international affairs at GW. Having lived with 23 years of essentially nonstop war, Iraqis had seen "the militarization of [their] politics and society, the brutalization of public culture, and the creation of irreconcilable divisions within Iraq," she writes. There has been some scholarly attention to the affects of long periods of war, but Dr. Khoury's book—based on government documents and interviews with soldiers and families—fills a void by casting the spotlight on Iraq. *—M.W.*



ORIGINAL COMET ART: ESA–C. CARREAU; ILLUSTRATION BY JOHN MCGLASSON

PLENTY O

BUT NO
FOR

AN ASTROBIOLOGIST'S
ORIGIN IS ABOUT TO LAND

/ BY DANNY

OF SPACE

ROOM

ERROR

SEARCH FOR LIFE'S
HER ON A SPEEDING COMET.

FREEDMAN /

The comet 67P/Churyumov-Gerasimenko, seen in this artist's impression, is the target of a first-ever attempt to land on one of these icy artifacts from the birth of the solar system.

Pascale Ehrenfreund was starting to get anxious about the summer.

It was only December when we met, but she was suddenly awash in the thought that the reading and thinking and preparations of the past 14 years were about to come to a head. Her mind was 520 million miles away, floating out near the orbit of Jupiter.

There in the frigid deep, the European satellite Rosetta was snoozing. Launched in 2004, Rosetta had carved a circuitous, sightseer's path to the outer solar system, where it was put into hibernation as it coasted toward the comet it will chase this summer at 62,000 miles per hour. In November a landing craft will grab it and, like a robotic Errol Flynn, ride the comet around the sun and into history.

Rosetta's alarm clock was set to go off in just over a month.

"After January 20," Dr. Ehrenfreund, an astrobiologist and research professor in the Elliott School of International Affairs, said at the time, "boom—it will really be a wake-up for everybody."

For the mission's engineers and scientists, and for sky-watchers of all stripes, the wake-up would set in motion a spectacular and unprecedented feat of cosmic derring-do; landing on a comet has never been attempted. Rosetta already is the first satellite to venture so far from home relying exclusively on solar power, and by the time it lands this fall, it also will be the first spacecraft to orbit a comet and observe it over time.

Yet the delicate orchestration of closing in on a comet and landing on its unknown surface is just the beginning for Dr. Ehrenfreund, one of the mission's scientists, and her colleagues. The orbit will give them a front-row seat as the sun brings the comet to a boil. And the landing will offer a chance to mine an artifact from the birth of the solar system, one that has been in cold storage for billions of years.

So when Rosetta blinked back to life on Jan. 20 after two and a half years of silence—sending an A-OK that traveled 45 minutes at the speed of light to reach Earth—the European Space Agency control room erupted into cheers and hugs. Dr. Ehrenfreund, receiving word while at a government dinner in Austria, could hardly sit and went table to table sharing the news.

"But right now," she cautioned in an email, "still 9 million kilometers to go."

It was nonetheless a monumental start to a new year—one in which she also plans to be part of an experiment sent to the International Space Station and will settle in as the first female president of the Austrian Science Fund, her home country's equivalent of the National Science Foundation in the United States. She also will be busy preparing to lead a space station experiment next year and, if all goes well, to land instruments on Mars in both 2018 and 2020.

It marked the start of another year of searching the stars for timeless and essential unknowns: the conditions under which the solar system was forged, the inventory of molecules in the universe, and unraveling the moment when chemistry became biology.

We are composed of the traces of stars, cobbled together from materials they produced in life and rocketed out in their fiery deaths; "starstuff pondering the stars," as astronomer Carl Sagan put it. And at this moment perhaps nothing in our galactic neighborhood is closer to that notion than the Rosetta spacecraft.

Both comets and asteroids are leftovers from the swirling gas and dust that formed the sun and accumulated into its surrounding planets, but comets are the "more pristine" artifacts, says Dr. Ehrenfreund.

While asteroids are rock or metal and reside mostly in an asteroid belt between Mars and Jupiter, comets are so-called dirty snowballs, conglomerations of ice, gas, and dust that were flung beyond the planets to the cold outer reaches of the solar system. Cometary ice has preserved easily vaporized elements that asteroids lost long ago. "Asteroids," she says, "have just had a rougher life."

Scientists think that comets may have brought water and the molecular ingredients of life to a young Earth, or added to what was already here. Carbon, for instance, is the basis of biology as we know it, and the comets and asteroids that pummeled the planet for hundreds of millions of years delivered it by the truckload: perhaps a million

Dr. Ehrenfreund, a research professor of space policy and international affairs, is among the mission's scientists who will study the comet for clues about the origin of life on Earth.
OPPOSITE **An artist's impression Rosetta's lander, Philae**

WILLIAM ATKINS

tons each year, by one estimate. That barrage of impacts helped make the Earth inhospitable at the time, Dr. Ehrenfreund says, but may have sown the seeds of life, which arose fairly soon afterward, some 3.5 billion years ago.

"We don't know what the early Earth did with all this material. We can't prove it, but we can research what is possible," she says.

Whether the necessary ingredients were imported from space or homegrown, or both, "the fact that you get this prêt-à-porter with asteroids and comets, you cannot ignore that," she says. "So that's why we need to know the composition of those objects."

Through Earth-bound observations and satellite missions, scientists so far have been able to discern a lot about comets: from their orbital paths, to the nature of their icy nuclei (which are among the darkest objects in the universe) and of the jets of gas and dust that in some comets form the characteristic haze, or coma, around the nucleus and a tail, which can streak across millions of miles.

Satellites have conducted observational flybys, collected samples of escaping dust and gas, and even smashed into one comet with a coffee table–size probe. Dozens of molecules have been identified in comets, including one type of amino acid—chemicals that are the building blocks of proteins, which drive essential functions for life on Earth.

All of these missions have had "an incredible impact on increasing our knowledge," says Dr. Ehrenfreund. "But it is not a piece of the nucleus."

In that sense, everything that the Rosetta mission finds on the comet stands to be something of a breakthrough, whether it reveals molecules that had gone undetected—or had changed chemically by the time they were found off the comet—or simply confirms and quantifies what was thought to be there.

Studying a comet from the surface also could provide unparalleled insight into its internal structure. "Those questions about porosity and layers and dynamics between ice, gas, and rock in a comet are important to understanding what actually comes down to Earth, what survives, [and] what would help to create something new upon impact," she says.

Rosetta's target is the comet 67P/Churyumov-Gerasimenko, which is about two and a half miles in diameter and oval-shaped. Although it used to be much deeper in space, close encounters with Jupiter over the past two centuries have gradually pulled the comet closer in, and it now swings by the sun every six and a half years.

As Rosetta chases the comet over the spring and summer and enters its orbit in August, the satellite will be studying it from a distance through a fleet of cameras, sensors, and other instruments. Among them is a microscope capable of analyzing individual grains of dust flying from the comet, which Dr. Ehrenfreund is involved with as a member of the instrument's science team.

The lander, called Philae, is expected to touch down in November and will study both the surface and below, using a drill that will plunge nearly a foot into the comet. Dr. Ehrenfreund is involved with a lander instrument that will search for complex carbon-based molecules, which could include amino acids or other organic molecules that are potentially significant to life on Earth.

The hope of the European Space Agency is that Rosetta will do for planetary science what its namesake did for the understanding of Egyptian hieroglyphic writing.

"Imagine you are reading something but you cannot understand the meaning of it because you do not know the letters, the symbols, the signs that are being used," said Alvaro Giménez, ESA's director of science and robotic exploration, at a news conference on wake-up day. "This is the situation we find ourselves [in] when we try to tackle the big questions about our place in the universe."

The comet "is made out of material that is linked to the infancy of our solar system—it's pristine, noncorrupted material, giving us information [about] the gas and dust nebula that gave birth to our entire solar system," Dr. Giménez said.

Exploring the comet "will be like opening a window in time."

It's not what usually comes to mind when someone refers to leading a "double life." Torn between studying genetics and astronomy in college, Dr. Ehrenfreund took a road less traveled: She pursued them both.

It was a decision that resulted, not surprisingly, in some missed parties. But that broad focus would position her in the late 1980s and '90s to jump into an emerging field at the intersection of both subjects.

After college at the University of Vienna, she earned a master's in molecular biology and a PhD in astrophysics. Only a few months separated her thesis work, which involved "extracting enzymes from the skin secretions of [African clawed] frogs," and her PhD research, observing carbon molecules in interstellar space, she recalled in an essay in the journal *Astrobiology*.

In 1999, just nine years after Dr. Ehrenfreund received her PhD, an asteroid was named in her honor—a designation that is made by an asteroid's discoverer (in this case, a renowned asteroid-hunting team led by Dutch astronomer Cornelis Johannes van Houten) but also must be approved by an international governing committee. The citation for "9826 Ehrenfreund 2114 T-3" notes her work on cosmic dust, organic molecules, and fostering international cooperation.

"They told me it's quite a nice object," Dr. Ehrenfreund says. (She

INSET, PHILAE LANDER: ESA/ATG MEDIALAB

hasn't actually seen it. To get a good look would require a high-powered telescope, and time slots on those are usually reserved for, well, science. "Just saying, 'Oh, I want to see my asteroid,' doesn't really work.")

By 2008 she already had become a highly cited researcher of ices and organic molecules in the vast spaces between stars. She had served as a professor of astrobiology in the Netherlands, as a scientific adviser and a committee member helping to steer the work of space agencies, and as a visiting scientist and consultant at NASA's Jet Propulsion Laboratory in California.

She was by then also a veteran of astronomical observations from some of the world's premier optical and radio telescopes and had served on the science teams of several space missions, from the early days of Rosetta, to experiments that exposed organic and biological materials to the space environment, to helping design an instrument for detecting organic molecules on a 2018 mission to Mars.

In 2008 she became a GW research professor of space policy and international affairs in the Elliott School's Space Policy Institute. And although policy is a decidedly terrestrial pursuit, it's inextricably bound in the exploration of space, from where to go and what to do, to how it's preserved, and how any of that gets funded.

As Dr. Ehrenfreund and her co-authors write in a recent article, as members of an advisory group to the European Commission: Plans for space exploration and Earth observation "are becoming more and more technically complicated and so costly that a single nation can hardly afford to realize them."

The sustainable way forward will be through new ideas about collaboration, Dr. Ehrenfreund and her colleagues write in a 2011 report. That means partnerships not just among today's big-league space agencies and the up-and-comers, like China and India, but also with developing nations interested in sparking technological growth, and with people from overlapping fields, such as earth science and space law.

That paper, which Dr. Ehrenfreund co-authored as chair of the international Committee on Space Research's Panel on Exploration, outlines a series of "stepping stone" opportunities, which include international coordination of studies into extreme environments on Earth; joining forces to defray the costs of high-priority robotic missions to bring home samples from asteroids, Mars, and other objects; and a program to support a class of increasingly sophisticated, small, lightweight, and low-cost satellites that can essentially piggyback to space aboard other missions.

She helped lead one of these missions for NASA in 2010, launching a loaf of bread-size satellite that demonstrated the capacity of so-called nanosatellites to carry out astrobiology experiments. Based on its success, she's leading a follow-up experiment for the International Space Station, planned for next year.

It's Dr. Ehrenfreund's search for the ingredients and origin of life, however, that will push back into the foreground with Rosetta and her planned Mars missions. The findings might fuel something deeper, too: a theory for how it all came together.

"I also work on something that is a little outside the mainstream," Dr. Ehrenfreund says. "I do not believe that life at the beginning was composed of the compounds which we are using now, in modern biochemistry."

One of the prevailing theories is that the first organisms were built using ribonucleic acid, or RNA, as a precursor to the current genetic molecule, DNA—an idea known as the "RNA world." RNA still plays a vital role in life, decoding genetic instructions for making proteins, among other things, and is made with nearly the same ingredients as DNA: a set of carbon-and-nitrogen compounds called nucleobases, sugars, and phosphates. Each of those, or their precursors, has been found in space or in meteorites (fragments of asteroids and comets that survive the fall to Earth).

But the Earth was a different place billions of years ago, and Dr. Ehrenfreund thinks the environment likely was too hostile for "very fragile molecules" like sugars and meteorite-bound amino acids.

"I think you should start very simple: What was there at the very beginning, and what could withstand the radiation, and thermal and geological activity, and could be versatile enough to be incorporated into the first protocells?" she says.

The answer, she thinks, is simpler but sturdier molecules called aromatic hydrocarbons.

These honeycomb-like chains of carbon and hydrogen atoms—"aromatic" in this case refers to a type of chemical bond—represent the largest portion of solid carbon in the universe. Among carbon-containing gas molecules, too, a group called polycyclic aromatic hydrocarbons, or PAHs, is the most abundant; on Earth they are seen when carbon-based material is burned incompletely, such as in vehicle exhaust and chargrilled meat.

The availability and robustness of these compounds have led Dr. Ehrenfreund to contemplate life's beginnings as an "aromatic world." In 2006 she led a team in formally making the case for it in the journal *Astrobiology*. The argument builds in part on an earlier hypothesis about PAHs guiding the formation of a DNA-like genetic blueprint molecule. But her team's hypothesis goes beyond that, envisioning vital roles for PAHs and other aromatic hydrocarbons in the construction and operation of life's other requirements, as well: energy-harvesting mechanisms and the cellular structure.

"In looking at life as we know it, or as we don't know it, we have to follow the basic rules of the universe," Dr. Ehrenfreund said at a NASA-organized conference that year. "We have to understand abundances and distribution. The inventory is strikingly similar everywhere." From a carbon perspective, she said, the universe "is absolutely aromatic."

As she works to build the case in the lab—a 2012 study found PAH derivatives helped stabilize a simulated primitive cell wall, similar to cholesterol in modern cells—she does so knowing that the unknown and perhaps never knowable details loom for any theory of life's origin. Still, there's much that can be done to fill in the picture. And comets, she says, remain "a big question mark."

"Everything we can measure to help us understand the organic inventory of comets will be a big breakthrough," she says.

Aromatic hydrocarbons and amino acids will be among the complex organics the Rosetta team will look for when the lander digs into comet 67P/Churyumov-Gerasimenko. While none on their own is likely to be a smoking gun, in total they may reveal much about an ancient chemical symphony and its potential for sparking life here—and maybe elsewhere, a prospect Dr. Ehrenfreund has not ruled out.

At that 2006 NASA conference, she closed her remarks by echoing a sobering thought from evolutionary paleobiologist Simon Conway Morris: "Life may be a universal principle, but we can still be alone."

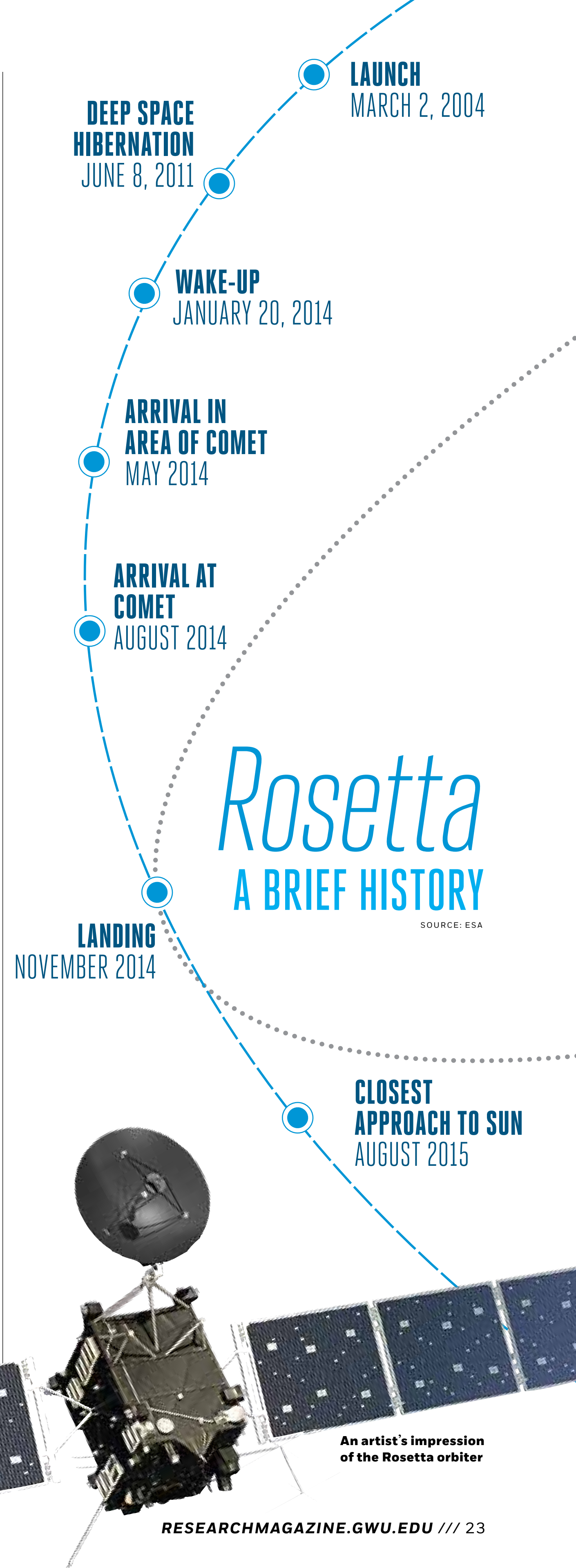
Her own hunch is somewhere in between endless solitude and a crowded universe.

Of the possibility for primitive life beyond Earth, she says, "we cannot exclude it whatsoever." The universe is big place. There are hundreds of billions of galaxies, and ours alone is thought to have a similarly vast number of stars. Many of those have planets, some of which may be habitable.

But finding similar life-forms? "To have exactly the same arising somewhere else, like us humans, I would be astonished. It is difficult to reproduce all these fantastic things that happened on our planet."

Asked whether she thinks life is out there, or if she shouldn't say, she replies, "I hope so," with a laugh.

"I am a scientist, so I have to be correct. I cannot say there will be; I cannot say there will not be," she says. "I would just say: It would be real fun." GWR



An artist's impression of the Rosetta orbiter

ROSETTA ORBITER: ESA/ATG MEDIALAB

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TINY, FLEXIBLE ELECTRONICS—WIRED WITH LIQUID METAL AND ABLE TO ANALYZE A FRACTION OF A RAINDROP—SOON MAY BE COMING TO A BODY NEAR YOU.

BY HELEN FIELDS

WILLIAM ATKINS

Zhenyu Li, assistant professor in the Department of Electrical and Computer Engineering, is holding a new invention between his thumb and forefinger. It looks like a piece of hard, clear plastic, about the size of a pack of gum. Inside are some fine wires and a square chip.

But then he squeezes his fingers together. The device bows upward and a tiny amount of liquid squeezes from the inside. "This will be a little messy," he says, grabbing a piece of paper towel.

The liquid he's wiping off is a gallium-tin alloy. Inside that fat piece of flexible material is an electronic sensor with a very unusual set of wires: They're tiny channels filled with liquid metal.

Dr. Li and his colleagues at GW's School of Engineering and Applied Science are figuring out how to make electronics bendable. They've applied for a patent on their solution to the problem, which combines a tiny integrated circuit chip with liquid wires to make a finished product that is—well, floppy. Dr. Li wraps it around his index finger to show how far it can bend.

Researchers around the world are working on flexible electronics that could show up in all sorts of places—a computer monitor that can be rolled up and stowed, for example. For now, the GW team is developing a device for medical diagnostics. Its flexibility means it could bend and stretch with the skin. One day something like it might be part of an implanted device, to monitor blood glucose or take other internal measurements.

Dr. Li's lab is a small room with a lot of tables and shelves, loaded with machines and materials. Drawers hold all kinds of electronic doodads, like LEDs and resistors; on a counter is a plastic board with wires sticking out of it, with a smartphone lying nearby—part of a student project.

A few days earlier, Dr. Li says, three graduate students and two undergrads were working in the cramped space, which is already feeling a bit crowded with just two

UNDER THE MICROSCOPE, THE SQUARE SENSOR COMES INTO FOCUS. IT'S TINY—ONLY 1.5 MILLIMETERS ON A SIDE. **FOUR OF THESE CHIPS** COULD LINE UP SIDE BY SIDE ON THE TIP OF A PENCIL ERASER.

professors and a writer. Shelves are crammed with everything from disposable tissue wipes to an ELISA machine, which performs a certain kind of biological assay, on a top shelf high above the refrigerator.

Dr. Li sets the device under one of the many microscopes in the room and switches on the light. The silicone rubber glows yellowish.

Under the microscope, the square sensor comes into focus. It's tiny—only 1.5 millimeters on a side. Four of these chips could line up side by side on the tip of a pencil eraser. From the chip emanates a tight array of tiny tunnels, each filled with liquid metal. These are the wires. Unlike the copper wires traditionally used in electronics, these wires still work when they're folded and stretched. All of the chip's 40 contacts are wired up for the sake of testing; if it was being used for real there might be just a few wires, to get power from batteries or to carry the output data to a communication chip.

Dr. Li is an expert in microfluidics—moving tiny amounts of liquids through minuscule tunnels. The channels through his device are 80 microns wide, about the diameter of a human hair. The most obvious ones are the wires.

But the part that got Dr. Li started in the project is a barely visible tunnel that starts at a hole on the surface of the block of silicone rubber, loops over the chip, then exits again, parallel to the way it came. It solves a particular challenge: how to deliver a tiny amount of liquid to a sensor.

When Dr. Li came to GW, in 2010, professor Mona Zaghloul, the chair of the Department of Electrical and Computer Engineering, and one of her graduate students were working on designing a tiny sensor that could detect a molecular marker of breast cancer in blood.

It's easy to imagine times when it might be nice to work with only a tiny amount of liquid—sometimes only a tiny amount of DNA is available for analysis, for example. For infants, taking a large blood sample is difficult. Researchers have been trying to figure out how to miniaturize various machines that work with liquids.

But there are practical problems with designing a tiny sensor. You can't pour a liquid sample on a chip for the same reason that you can't dunk your phone in the bathtub: Electronics and liquid do not mix. So Dr. Zaghloul was thrilled to have Dr. Li, an expert in moving tiny liquid samples, join the department. "The first time I met him, I said, 'Can you make me a well to put that liquid on top of that sensor?'"

Dr. Li made that well, and it worked. But it wasn't perfect. The well still held a relatively large amount of liquid, 10 microliters—about the volume of a smallish raindrop—and the arrangement was awkward. Also, they had no way to clean out the well, so the chip could only be used once. Still, it worked. "It detects the cancer biomarker," Dr. Zaghloul says. "The student got his PhD!"

They tried again with a sensor that another of her students was working on: a chip that measures magnetic nanoparticles in fluid. Biologists sometimes use magnetic nanoparticles to tag specific molecules. Measuring the magnetic field tells you the concentration of the target molecule.

Dr. Li had an idea: What about a microfluidic channel that pumps the test liquid over the chip? It could use a smaller volume—and they'd be able to clean it out.

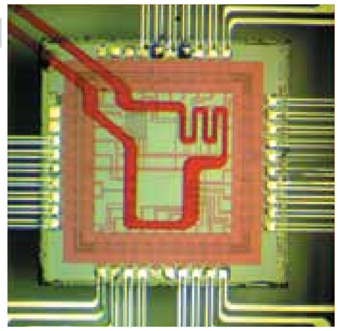
Dr. Li works in the medium of silicone rubber. It's cheap, easy to mold, and easy to punch holes in. Technically known as PDMS, for polydimethylsiloxane, it's the preferred material for microfluidics—and it's also used in Hollywood, to make gory wounds and creepy monster faces.

Dr. Li starts by designing the channels he wants, using industrial design software. Then,

WILLIAM ATKINS

MICROSCOPIC VIEW

Beneath the lens of a microscope, a warren of liquid-metal connections comes into view, extending from the contacts to the sensor. The patent-pending technology could lead to an implantable device for monitoring blood glucose or other metrics.



SENSORY DETAIL

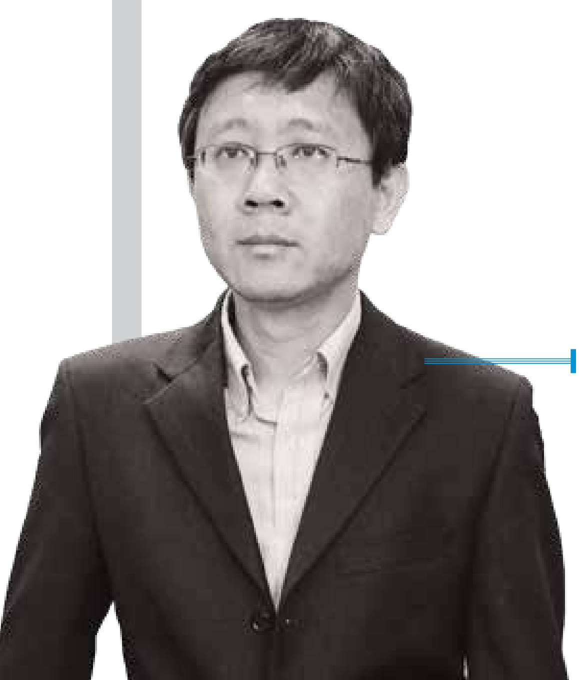
The tiny chip (below and enlarged at right) is powered by a network of channels filled with liquid metal, which allows the device to be flexible and still work. Fluid to be analyzed is carried across the sensor via another channel (at right, in red), which holds about 10 nanoliters, or about one-thousandth of a raindrop.

SILICONE VALLEYS

The body of the device is made of silicone rubber, which Dr. Li pours into a mold to create the tunnels, and then bakes. A biopsy needle is used to punch holes down to the tunnels, and liquid metal is poured in.

BLOOD WORK

As an implanted medical device, fluid for analysis would be drawn in through a hole at the surface and pumped over the sensor then back again, where it would exit through another hole. One of Dr. Li's students is designing channels that might be able to separate different kinds of blood cells.



THE PROFESSORS

Assistant professor Zhenyu Li (left); Department of Electrical and Computer Engineering Chair Mona Zaghloul; Associate Dean for Research and Graduate Studies Can Korman

WITH SOME ADAPTATIONS, SOMETHING LIKE THIS DEVICE COULD BE USED TO DIRECTLY MONITOR MOLECULES IN BLOOD.

using standard techniques for manufacturing computer chips, he makes a hard, shiny silicon wafer with the shape of the channels standing up on it, in relief. This works just like a Jell-O mold. He mixes the PDMS polymer from its two components, pours the polymer onto the mold, then puts it in the oven for 30 minutes or so to set.

When the polymer is baked, he glues it to another piece of silicone rubber that has the sensor embedded in its surface. He uses a biopsy needle to punch holes down to the wires, then fills them with liquid metal. Like mercury, the gallium-tin alloy is liquid at room temperature. Unlike mercury, it's pretty safe. A five-milliliter jar of the liquid metal costs several hundred dollars, but that much metal can make thousands of microfluidic wires; the cost of the metal in a single device is less than 10 cents.

When the wires and sensor are all hooked up, Dr. Li can push fluid through the sample delivery channel with the help of a bit of compressed air. The channel holds about 10 nanoliters, roughly one one-thousandth of the volume that went in the well on the previous chip. After use, Dr. Li can clean it out by pushing the sample out with a syringe, or he can draw the liquid out by putting an absorbent pad at the end of the channel.

The best part: Because everything except the chip is flexible, the resulting device can bend and stretch.

There's no particular reason that a device to measure magnetic nanoparticles would need to be flexible and stretchable. But this was a convenient way to work out the flexible, stretchable design, and it's easy to imagine other applications, Dr. Li says. For example, it could stick onto the skin—a flexible, stretchy organ—to soak up liquid in the form of sweat or tears. A contact lens made using this principle could detect a condition in tears, while taking only a few microliters of liquid. It might be able to monitor electrolyte or alcohol levels in sweat. It wouldn't need a pump; water soaks into the device by itself.

With some adaptations, something like this device could be used to directly monitor molecules in blood. For example, it's long been a dream for diabetes experts to develop an artificial pancreas that would monitor glucose levels in blood and use that information to deliver insulin. A device like this could fit unobtrusively into the body and could sample blood with help from tiny pumps and other miniature devices.

Can Korman, associate dean of research and graduate studies and a professor in the Department of Electrical and Computer Engineering, collaborated with Dr. Zaghloul and Dr. Li on the device; he worked out how the magnetic nanoparticles in the fluid would interact with the electronics on the chip.

It goes beyond medical devices, Dr. Korman says. "There's a whole field about how to make electronics flexible." One major area of research has been on solar panels; now they're rigid and have to be handled carefully, but manufacturers would love to have the option of a solar panel that is flexible and cheap.

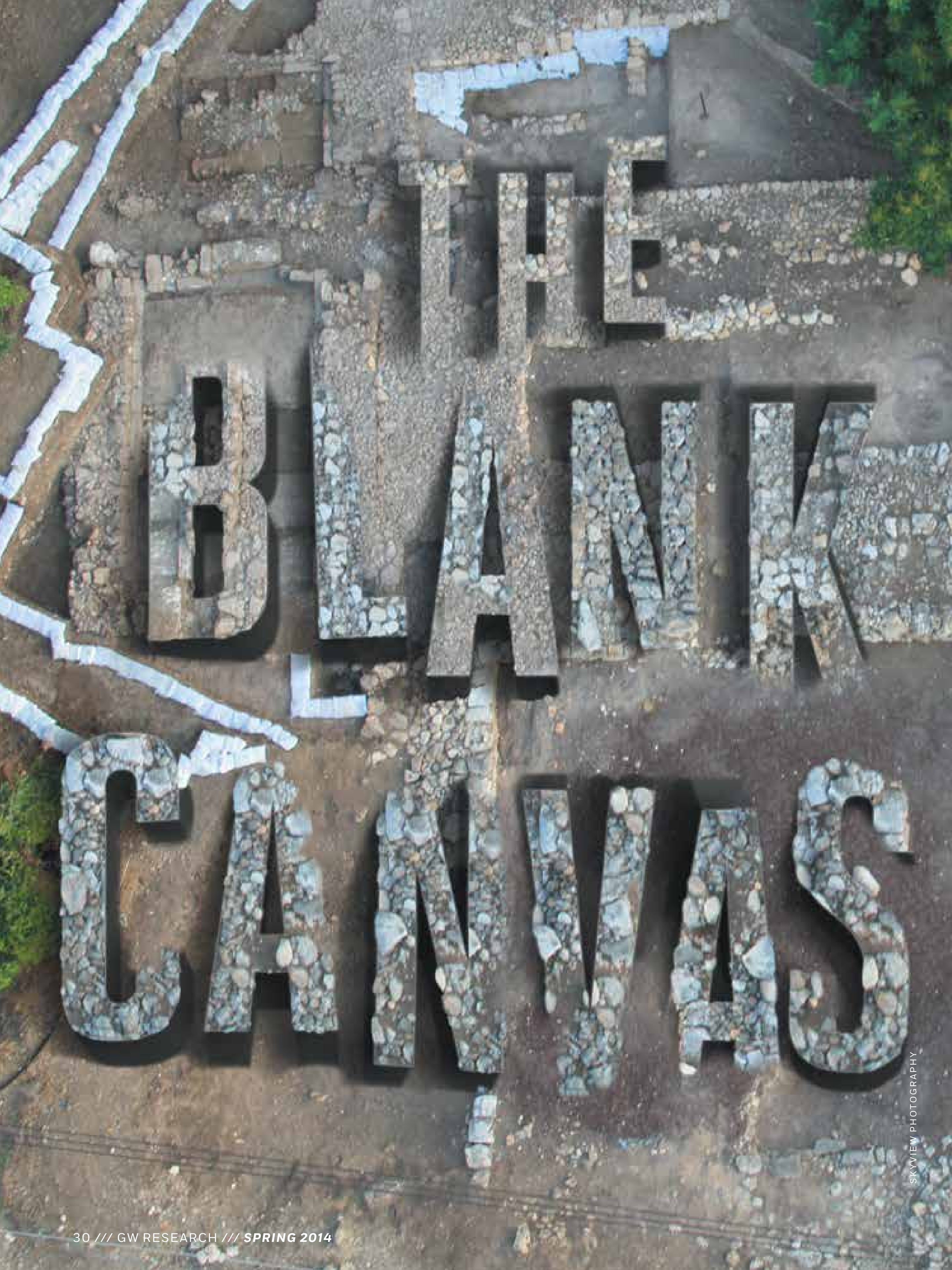
"Our immediate thought was a biomedical application, but it could be many other things," he says.

Another example is a laptop or cell phone that can roll up and go in a pocket. Even if the electronic components are rigid, they could be embedded in a flexible substrate and make up a flexible product, the way that thousands of metal rings come together to make a flexible piece of chain mail.

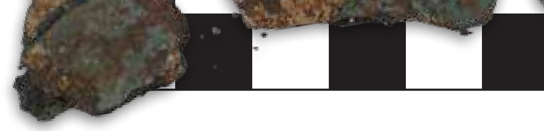
For now, the team has applied for a patent, and Dr. Li continues his work on microfluidics. One of his students is designing microfluidic channels that might be able to separate different kinds of blood cells. Another is using silicone rubber and liquid metal to make tiny lenses.

And he's looking forward to having a new workspace next year, when the Science and Engineering Hall opens. Till then, he or a student must take a whole day to go to the University of Maryland or the National Institute of Standards and Technology, in Gaithersburg, Md., when he needs to manufacture a new mold for silicone rubber; the new building will have a clean room. He'll be able to get some of his machinery out of storage, too.

He looks at his small, messy lab. It looks like the kind of place where people really are inventing things. "The messy part you expect, but the space is really limited right now," he says. Next year, he hopes, the electronics will be smaller and the possibilities greater. GWR



SKYVIEW PHOTOGRAPHY



An aerial view of Tel Kabri, a 75-acre site in northern Israel that houses the ruins of a Canaanite city dating back to around 1800 B.C., during the Middle Bronze Age. The site is one of four in the eastern Mediterranean—together with sites in Egypt, Syria, and Turkey (mapped below)—that seems to bear the influence of Western art.

In the remains of a 3,800-year-old palace, archaeologists seek clues about social, political, and economic life in ancient Canaan.

BY LAUREN INGENO

In bare feet and socks they dug, from before dawn until dusk.

Inside the ruins of a Canaanite palace, an international team had uncovered a three-foot-long ceramic jug on day two of a six-week expedition in northern Israel. When a few more days of digging revealed that 39 others—delicate and cracked but mostly intact—were buried in the same storage room, the summer excavation turned into a frenzied race against time.

"It was both a curse and a blessing," says GW professor of classics, anthropology, and history Eric Cline, co-director of the dig at Tel Kabri, the onetime capital of a Canaanite territory and now one of Israel's most elusive archaeological sites. "This is the type of thing you want to find, and yet, by the time we realized how many jars were in there, we were halfway through the season. Once they were exposed we had to get all 40 of them up, since they wouldn't have survived the winter."

LEFT **Zach Dunseth, BA '09, removes dirt from wine jugs found at Tel Kabri. More than 100 GW students have learned to dig at Tel Kabri and Megiddo.**

To complicate matters, the ancient 375-square-foot storage room could accommodate only around 15 people. So the group did something unorthodox: Half of the team of more than 60 volunteers dug during typical hours—from 5 a.m. to 1 p.m.—and the others worked from 2 p.m. to 7 p.m., under the grueling July sun. Shoes and sandals were left behind to prevent damage to the fragile artifacts.

With two days to spare, the group was able to successfully excavate and preserve each of the 40 jugs. In the fall, Dr. Cline and his colleagues announced that organic residue analysis confirmed what the team suspected: The archaeologists had struck wine.

The 40 jugs have a combined capacity of around 2,000 liters, or the equivalent of 3,000 wine bottles, meaning the team had dug up what could be the oldest and largest palatial wine cellar in the Near East.

"It is a wine cellar that, to our knowledge, is largely unmatched in its age and size," says Dr. Cline.

The finding deepened the intrigue of a site that has baffled Dr. Cline for the past decade. Though relatively unimpressive on the surface, the site is best known as one of only four sites in the eastern Mediterranean that seem to bear the influence of Western art, stemming from the area of modern-day Greece. It also offers a unique opportunity to gain insight into the little-understood life of the Canaanites, and just the right amount of mystery: Despite no clear signs of destruction, the site was abandoned after just 300 years of Canaanite occupation, never again to be populated.

"Who were the people who lived there? And why did they leave?" Dr. Cline muses. "Who ruled the palace? And why were they so preoccupied with Aegean art?"

Missing Pieces

To find Tel Kabri, travel north.

The 75-acre site, surrounded now by lush plantations of bananas and avocados, is located in the western Galilee region of Israel, less than three miles inland from the Mediterranean Sea and a 10-minute drive from the modern resort town of Nahariya.

Tel Kabri is Israel's third largest site from the Middle Bronze Age (2000-1500 B.C.), following Hazor and Ashkelon. Much is still unknown about the history of Tel Kabri, including the city's ancient name. Its main structure, which dates around 1800 B.C., is presumed to be a palace based on its enormity—roughly the size of two football fields, with walls constructed of mud brick—though evidence of a king or queen has yet to be found at the site.

"Somebody had to have the manpower and the money to build it. And usually, only a ruler could do that," Dr. Cline says. "Personally, I think it's royal. But there's no proof for it—yet."

Archaeologists are certain that the palace was built and inhabited by a Canaanite civilization for about 300 years during the Middle Bronze Age, which, in biblical terms, was between the time of Abraham and Moses. Canaan was a large and prosperous country that included present-day Lebanon, Syria, Jordan, and Israel, until the territory was conquered by Israelites during the second millennium B.C.

But Tel Kabri is highly unusual in that after it was abandoned no other settlements were built on top of it. Other archaeological sites might have a dozen or more layers of ruins left by many generations living and rebuilding on the same spot.

"I don't know why no one ever reoccupied it, especially since there is plenty of water there," says Dr. Cline. "We also don't know how or why it was destroyed. There is no evidence of an earthquake, a fire, or any other great destruction. They just stopped living there. It's very strange."

Because of that, Tel Kabri is the only Canaanite city from the Middle Bronze Age that can be excavated in its entirety. And since so little is known about Canaanite society—including its status groups, political structure, and economy—excavating one of the world's best-preserved Canaanite

TOP **Two of the 40 three-foot-long ceramic jugs discovered last summer** MIDDLE **Team members remove debris from one of the wine jugs** BOTTOM **Eric Cline, chair of the Department of Classical and Near Eastern Languages and Civilizations and co-director of the dig at Tel Kabri**

ALL: ERIC CLINE

palaces is critical to understanding the ancient civilization, says Assaf Yasur-Landau of the University of Haifa, who co-directs the dig at Tel Kabri with Dr. Cline.

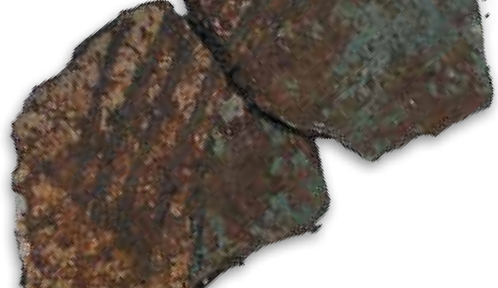
“Kabri is also a fantastic case study to learn about the development of Canaanite urbanization and rise of political power,” Dr. Yasur-Landau says, “as we can follow the rise of Canaanite palatial elite from its humble beginning at private houses to the rise of the palace, all during the Middle Bronze Age.”

Lost and Found

Though the site was first discovered in the 1950s, when members of Kibbutz Kabri found Late Neolithic stone artifacts near a local spring, it was the national public water company that stumbled upon the Middle Bronze Age palace, in 1961, while installing a pipeline.

Small-scale excavations then uncovered the plaster floors and other artifacts, and the first comprehensive dig got under way in the mid-1980s, led by Aharon Kempinski of Tel Aviv University and Wolf-Dietrich Niemeier of Heidelberg University.

In 1989, Dr. Kempinski and his team uncovered an elaborate, Aegean-style painted floor in the ceremonial hall of the palace, decorated in a red checkerboard motif, with pictures of irises and crocuses painted into the squares. The archaeologists also uncovered around 2,000 colorful fragments, all painted in a distinctive Aegean style. On the fragments, they saw string impressions, which were used in fresco painting as guiding lines during the Middle Bronze Age—a technique not commonly found in eastern Mediterranean art. By comparing the fragments found at Tel Kabri with other Aegean wall paintings that depicted similar motifs, colorings, and line shapes, the archaeologists were able to



ABOVE AND BELOW: **Fragments from the site with Aegean-style brushstrokes; the blue paint is the first of its kind from the Middle Bronze Age found in Israel**

reconstruct hypothetical miniature frescoes of hill and sea landscapes.

Before the discovery, Aegean-style artwork—characterized by breezy depictions of nature, fluid figures, and bright colors—had never been found beyond the islands of the Aegean, which includes Crete, the Cyclades, and the Greek mainland. The frescoes and floor painting are especially unusual because regional artistic influence in Canaan typically came from Mesopotamia in the north, where present-day Iraq is located, not from the Aegean Sea to the west.

To date there are only three other sites where this Aegean-style artistry has been found—Tell el-Dab'a in Egypt, Qatna in Syria, and Alalakh in Turkey.

"In archaeology we refer frequently to what's called a *koiné*, a Greek word meaning commonality. We're wondering if there was some kind of artistic koiné, where people in the eastern Mediterranean were looking to the Aegean for influence, for whatever reason," Dr. Cline says.

Dr. Kempinski died unexpectedly in 1994, and the Tel Kabri excavation project came to a sudden halt. Though he never saw the final publication of his findings come to fruition, the archaeologist considered the Tel Kabri site to be "one of the most important in Israel," Dr. Niemeier writes in the introduction of *Tel Kabri: The 1986-93 Excavation Seasons*.

The site remained untouched until 2003, when Dr. Yasur-Landau of the University of Haifa returned to northern Israel to conduct remote sensing at Tel Kabri. This revealed that the palace was twice as large as Dr. Kempinski had originally thought.

When he approached Dr. Cline about the possibility of reopening the site, the offer was too good to pass up. At the time, Dr. Cline had never led his own dig, and the excavation would give him the rare opportunity to open a new window into Canaanite society and its interaction with the Aegean world.

"Assaf came to me in 2004 and said, 'You want to reopen Kabri?' And I said, 'Sure, I'll be in touch,'" says Dr. Cline. "That was that."

Since excavations restarted, taking place every two years since 2005, each digging season at Tel Kabri has proved more successful than the last. On the summers that Dr. Cline is not excavating at Tel Kabri, he co-directs another dig in Israel, at Megiddo—the site known as the "the jewel in the crown of biblical archaeology." For more than 6,000 years, the city dominated international traffic, as it was located above the most important land route in the ancient Near East. Within its 25 layers of settlements, archaeologists have uncovered chariot stables, gold jewelry, monumental temples, and remarkably engineered water systems.

With Kabri, though, it's precisely the lack of layers and context that makes it significant.

"At Megiddo we're more filling in the gaps," Dr. Cline says. "At Tel Kabri, it's really a blank canvas."

A Link to Greece

During the 2009 and 2011 excavations at Tel Kabri, Dr. Cline, Dr. Yasur-Landau, and their team members uncovered even more fragments of Aegean-style painted wall plaster, as well as fragments from another painted floor.

The fragments vary in quality and size but add valuable information about the artistic plan of the palace and its sources of artistic influence. Of these, the most intriguing collection is composed of five bright blue fragments, which, when pieced together, depict part of what is likely an animal painted in black ink. Dr. Cline says the blue paint is the first of its kind from the Middle Bronze Age that has been found in Israel. Without all of the pieces, he is not certain what the image once depicted. It could be the fin of a flying fish, or the wing of a griffin, or perhaps something else entirely. Judging by the thinness of the lines and the precision of the brushstrokes, it's clear to the researchers that this is the work of a skilled artist.

So who traveled all the way from the Aegean Islands or Greek mainland to paint the walls and floors at an eastern Mediterranean palace? And more important, why? Dr. Cline admits that he may never be able to definitively answer those questions, but he can make some educated guesses.

In the Middle and Late Bronze Age, rulers in Egypt and the ancient Near East often sent artisans on short-term loan to each other, so it's possible that Aegean rulers were part of a similar exchange network in the east. Or maybe the artists were moving around the region independently. But even so, why would the rulers at Kabri want to decorate their palace with Aegean art?

Despite its prominent position as a gateway community, Kabri was only a "secondary player" compared with other huge commercial cities, such as Hazor, Dr. Cline and Dr. Yasur-Landau write in a 2011 article in the *American Journal of Archaeology*.

The archaeologists suspect that the choice of the Kabri rulers to acquire Aegean art may have stemmed from their desire to show that they belonged to a "cosmopolitan" Mediterranean club. The foreign paintings might have been intended to impress the rulers' peers by showing they had exclusive connections to places outside of the Near East.

Recent excavations at Tel Kabri also revealed that the palace underwent significant architectural renovations, which resulted in the creation of a much larger building. The palace's fresco fragments were found facedown in the palace, which suggests that the Aegean-style art was torn down and discarded after the remodeling, while the palace remained in use. Some of the art was even reused, seemingly without sentiment, as patching on the plaster floor.

"It's as if they thought, 'Well this is garbage, and we have a hole that needs to be filled here, so let's just use it here,'" Dr. Cline says.

The explanation of this could be simply that Aegean-style art was going out of style, or maybe one ruler was going out, and a new one was coming in. Politics could also have been at play, but Dr. Cline says the paintings just as likely could have been removed for functional reasons. In Greece, he explains, frescoes stuck easily to the stone walls used there. By contrast, the Tel Kabri palace walls are made of mud brick, which does not hold plaster as well. Once the frescoes began to peel, the Canaanites may have decided to just rip them off the walls entirely.

One of the most revealing discoveries at Tel Kabri was the uncovering of a two-room, monumental structure designated as an "orthostat building," due to its extensive use of orthostats and ashlar paving stones. These types of upright slabs are rather rare in Middle Bronze Age Canaanite structures, again suggesting outside influence from the Aegean Islands or possibly even Syria.

To Be Continued

In summer 2013, with grants from National Geographic, the Israel Science Foundation, Bronfman Philanthropies, and the Institute for Aegean Prehistory, Dr. Cline and his excavation team were tasked with investigating the palatial economy of Kabri by comparing findings inside the palace with findings outside the palace—to look at the haves versus the have-nots.

The archaeologists aimed to locate the western edge of the palace, but instead they hit the remains of a storage room, where they found the 40 ceramic jugs. To date, it is the largest concentration of restorable pottery found anywhere in the palace and the only place on site where an entire room full of artifacts has been discovered.

The testing of organic residue in the jugs, by Kabri dig colleague Andrew Koh, of Brandeis University, found the presence of tartaric acid—a "surefire" marker of wine. Dr. Koh also found the samples contained local and possibly imported wine additives, such as honey, mint, resin, and juniper berries.

"This wasn't moonshine that someone was brewing in their basement, eyeballing the measurements," Dr. Koh says. "This wine's recipe was strictly followed in each and every jar."

And the ingredients mirror the very additives that are detailed in ancient texts from Mari, a Sumerian and Amorite city on the Euphrates River, located in what is now Syria.

"We have a physical manifestation of what you can read about in the Mari tablets," says Dr. Cline. He admits that it is not necessarily an indication that the wine found at Tel Kabri was imported from the Euphrates. "But it is still cool that something we've known about only from texts for decades, we now have scientific proof of its existence."

What other relics are hidden in the palace ruins? And how will the new discoveries help to tell the history of Tel Kabri? The excavation team won't be returning until 2015, but they have plenty to look forward to.

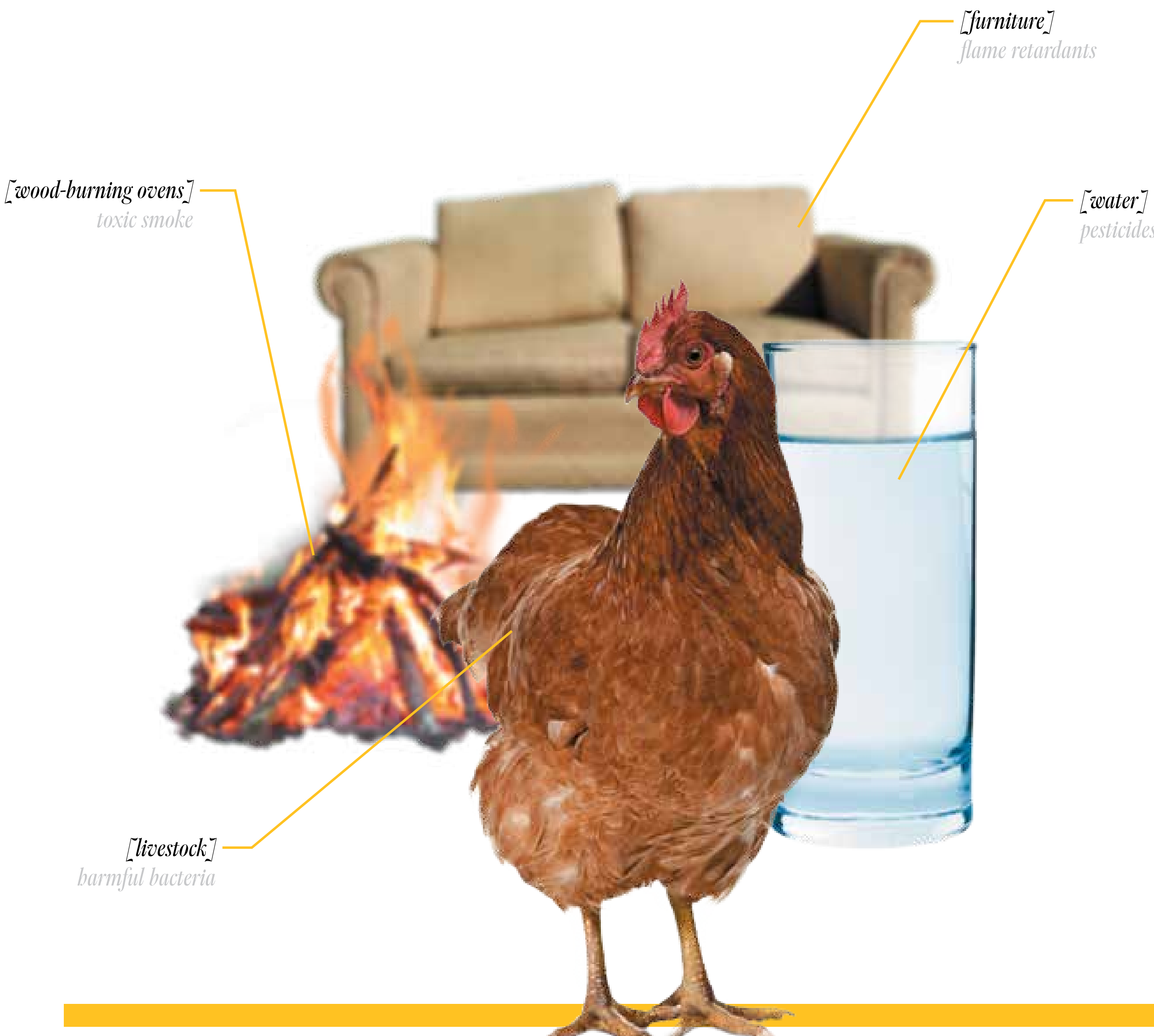
Just days before the archaeologists wrapped up their dig this past summer, they discovered two doors in the storage room leading to other chambers, one to the west and one to the south. In those rooms they spotted even more ceramic jugs. "Those are the first things we'll go after," Dr. Cline says.

If the jugs contain something other than wine, perhaps olive oil or wheat for instance, that could for the first time shed significant light on the Canaanite economy, he says. He's hopeful, and the excitement is palpable in his voice—in spite of the knowledge that the rubble may keep as many Canaanite secrets as it gives up.

"What it boils down to is that we need a time machine," says Dr. Cline. "They can't come back to tell you if you're right or wrong." GWR

Residue analysis of the jugs found a hallmark of wine, as well as additives like honey. Just before the dig season ended, other chambers were discovered with more jugs that now await the team's return.

ALL: ERIC CLINE



INSPECTING THE UNEXPECTED

BY AMANDA MACMILLAN

ENVIRONMENTAL HEALTH RESEARCHERS STRIVE TO IDENTIFY HIDDEN DANGERS IN OUR AIR, FOOD, WATER, AND HOUSEHOLD PRODUCTS.

For scientific research and public policy, there's no place like Washington. The capital city's diverse population, respected institutions, and federal fabric make it an ideal place for scientists to influence health across the nation. For faculty members in GW's Department of Environmental and Occupational Health, however, the city is just one part of the equation. In the past few years the department has become a force of change, leaving its mark everywhere from northeast D.C. to West Africa.

"As we have extended our ability to peer into the intricacies of the human genome, one thing that has become clearer is the very important role of the environment in health and disease," says Lynn Goldman, the Michael and Lori Milken Dean of the Milken Institute School of Public Health and a professor in the EOH department. "Progress in genetics has not been matched by progress in understanding environmental and occupational determinants of disease, and at GW we are exploring these issues on many fronts."

GW researchers are asking important questions about invisible threats all around us: in our air and water, our backyards, even our groceries and household products. And their findings are identifying dangerous exposures, ways to reduce the risks, and what needs to be done—in government, industry, and academia—to protect future generations.

IDENTIFYING DANGERS AT HOME

When department chair Melissa Perry arrived at GW from Harvard University in 2011, she brought with her extensive research on the health effects of pesticides. "My lab asks whether these chemicals have an impact on how hormones are produced in the body," says Dr. Perry, who in September will become president of the American College of Epidemiology.

Her early studies focused on farmers and farming communities, and she has since expanded her research to general populations that may come across pesticides only in public areas, like parks. A National Institutes of Health-funded study that she co-authored last year, for example, looked for links between sperm abnormalities and pesticides commonly used for home gardens and lawn care. (The study did find a link, and she says more research is needed.)

Among her current projects, Dr. Perry is investigating endocrine-disrupting pesticides in the Potomac River Valley and the Chesapeake Bay. "We know that these chemicals are entering the water and that they're affecting the ecosystem; we've had reports of various fish that now have both male and female sexual characteristics," she says. "I'm hoping to form a collaboration with local farmers, to figure out how we can reduce these sources of contamination."

Farmers are often portrayed as bad guys who willingly spread these harmful pesticides, Dr. Perry says, but they're actually the most serious victims when it comes to health effects. "They're using pesticides because their productivity depends on it, but no one is talking to them about their own health or their family's health," she says. By acting as an advocate for their safety, Dr. Perry hopes to work with farmers to develop alternative practices that are better for them, the environment, and the public.

Pesticides are just one type of endocrine disruptor the EOH department is tackling. Assistant professor Ami Zota has devoted much of her research to two others: flame-retardant chemicals, found in household products like couches and electronics; and phthalates, compounds used to make children's toys and fragrances.

Before joining the GW faculty, Dr. Zota made headlines for a 2013 study that found the levels of polybrominated diphenyl ether (PBDE) flame retardants in the blood of pregnant women in California had fallen by two-thirds

"There are basically a billion people out there who are working and living around animals, and they don't know the health consequences for themselves or their children."

—JAY GRAHAM

in the years following a state ban. Earlier this year, she published a similar report on phthalates present in urine samples collected from more than 11,000 children and adults over a 10-year period. While levels of several phthalates had fallen, she found, levels of others had actually risen—suggesting that newer chemicals were being substituted for older ones, with potentially the same health risks.

"These studies show that our actions really do matter," says Dr. Zota. "The good news is that when we collectively decide to target a certain chemical that might be bad for our health, we can do something about it. The bad news, though, is that we're not so good yet at figuring out what to replace it with, and these new ingredients may pose many of the same risks."

For the past few months, Dr. Zota has been building a research team to continue her work on endocrine disruptors, reproductive health, and pregnancy outcomes. A career-development award from the National Institute of Environmental Health Sciences has allowed her to forge a partnership with the university's OB-GYN clinic, from which she'll be recruiting patients for future studies. "Because our patient population here at GW is so diverse, it will really allow me to delve into reproductive health disparity issues, which is an important part of this research," she says.

Assistant professor Kate Applebaum is also spearheading a government-funded research project this year: Through a grant from the National Institute for Occupational Safety and Health, she's studying autoworkers in Michigan and their risk for chronic kidney disease and renal cancer later in life.

Metalworking fluids used in the auto industry contain compounds called polycyclic aromatic hydrocarbons, or PAHs, a potential contributor to kidney damage. By studying people with frequent, well-documented exposure, Dr. Applebaum hopes to determine, more definitively, its impact.

These compounds aren't just a problem for autoworkers, either. "PAHs are present elsewhere in our lives; they're even in our diets, for example, if we consume meats that have been grilled at high temperatures for a long time," says Dr. Applebaum. "Although I am studying PAHs in a specific occupational population, the findings will raise questions about the impact of PAH exposure on chronic kidney disease and renal cancer in the general population."

IMPROVING LIVING CONDITIONS ABROAD

Air pollution is another area of interest for the EOH department, especially for assistant professor Amanda Northcross, who studies its impact on people in Nigeria who cook their meals over wood-burning or kerosene stoves.

Three million people die prematurely every year from inhaling toxic smoke from these devices, Dr. Northcross says—and while there has been a global effort to reduce exposure through clean-cooking technologies, most of the research so far has focused on Latin America or East Africa and in rural areas. Hers is some of the first research to look at West Africa, and to be done in a relatively urban city.

Dr. Northcross' current research involves 300 pregnant women, half of whom have been cooking with their traditional methods and half of whom have been given clean-burning ethanol stoves. She is studying whether babies born to the latter group have higher birth weights, and therefore better health outcomes, than those in the former.

Meanwhile, assistant professor Jay Graham is studying other health concerns in the developing world: water, sanitation, and hygiene issues, and animal-derived infectious diseases. These issues are both major contributors to the one and a half million children who die every year from diarrhea worldwide—about 70 percent of them before the age of 2, explains Dr. Graham. "It's really important to create a hygienic environment while their immune system is still developing, but in a lot of cases these families and communities don't even know what a hygienic environment means."

As part of a four-year National Institutes of Health grant, Dr. Graham is studying small-scale livestock holders in Ecuador—families that own five chickens or two cows, for example—to see whether disease-causing bacteria are being transferred from those animals to humans, specifically children. He seeks to answer several questions: Are certain animals more dangerous than others? What about certain handling and housing practices—keeping chickens or guinea pigs in the house, for example, as opposed to outside or in a separate building?

The findings, he hopes, will have widespread implications for the two-thirds of rural, low-income families that raise their own livestock. "There are basically a billion people out there who are working and living around animals, and they don't know the health consequences for themselves or their children."

ADVOCATING FOR LASTING CHANGE

Back on U.S. soil, professor Lance Price is breaking new ground on the worldwide threat of drug-resistant bacteria.

In December, Dr. Price published a study revealing that one widespread strain of *E. coli* had become resistant to most common antibiotics, and that it appeared more adept at ascending from the

“These are baby steps in the right direction, but this is not the time to be taking baby steps. This is one of the biggest health crises of our time, and we should be running full speed in the right direction and putting some meaningful policies into place.”

—LANCE PRICE

urinary tract to the bloodstream, where infections can be deadly. That single strain, he says, may be responsible each year for 1.5 million urinary tract infections and tens of thousands of deaths in the United States.

More recently, Dr. Price’s research has suggested a link between UTIs in residents of Flagstaff, Ariz., and bacteria strains found in the meat and poultry sold in local grocery stores.

“This really changes the whole paradigm of what a food-borne infection can look like,” he says. “It’s not just diarrhea and upset stomachs anymore.”

His research team even coined a new term for this type of infection: FUTI (a play off the pop-culture term “foodie”), an acronym for food-born urinary tract infection.

Antibiotics used in factory farming—to make animals grow larger and to prevent diseases when housed in unsanitary spaces—are the most likely culprit behind the spread of such drug-resistant bugs, Dr. Price says. He advocates that people buy meat and poultry raised without antibiotics, but warns that even that won’t offer total protection: His research shows that these products can still contain antibiotic-resistant microbes, likely introduced to the animals through the air from neighboring farms or at slaughtering facilities that also process conventionally-raised livestock.

Even more than educating consumers, Dr. Price hopes his research will be used to inform evidence-based health policies.

He’s presented at congressional briefings and hearings several times in recent years, supporting legislation such as the Preservation of Antibiotics for Medication Act (which was introduced in 2013 but has only a slim chance of going up for a vote) and recent Food and Drug Administration guidelines that recommend against the use of antibiotics to increase animals’ growth rates.

“These are baby steps in the right direction, but this is not the time to be taking baby steps,” he says. “This is one of the biggest health crises of our time, and we should be running full speed in the right direction and putting some meaningful policies into place.”

Dr. Northcross is also involved in advocacy efforts close to home, serving as an adviser to a community group in Ivy City, a low-income section of Northeast D.C. Residents there are concerned about air pollution and high rates of asthma, and last year filed a lawsuit in an attempt to keep yet another parking lot for commercial buses out of their neighborhood.

In conjunction with researchers from Howard University, the University of Maryland, and Trinity University, Dr. Northcross has been working with the community on using air-quality monitors and collecting data on existing pollution levels to test whether they already may be higher than Environmental Protection Agency standards.

Kimberly Horn, the school’s associate dean for research, says Dr. Northcross’ research and advocacy is a perfect example of how the EOH department’s work has such real-life significance.

“She’s developing scales for air quality that can be used not just by scientists but by the people who live in those communities, as well,” says Dr. Horn. “Translating research so that it reaches community members in their everyday lives is such an important part of public health.”

Indeed, the department stands out for its ability to integrate meaningful science into policy and public health practice, says Dr. Perry, the department chair.

“Everyone here is very committed to ensuring that their research has direct relevance to policy and to practice,” she says. “We’re studying chemicals, superbugs, and chromosomes to garner new information, and we want to make sure that the information we generate can be used to change regulations and enhance public health protection.” GWR

'ENDLESS FORMS MOST BEAUTIFUL AND MOST WONDERFUL'

FROM THE NEWEST TWIGS TO THE ANCIENT LIMBS OF THE "TREE OF LIFE," RESEARCHERS TRACE THE CONNECTIONS BETWEEN ALL LIVING THINGS.

BY DANNY FREEDMAN

ILLUSTRATION: JAMES STEINBERG

Writing the words was "like confessing a murder." But, Charles Darwin continued in an 1844 letter, he had come to believe that species are not "immutable." They change, they evolve.

Fifteen years later, though still as heretical as it was revolutionary, the famed naturalist outlined his theory of evolution by natural selection in a book. He wrote lyrically of a "great Tree of Life, which fills with its dead and broken branches the crust of the earth, and covers the surface with its ever-branching and beautiful ramifications."

Biologists since have sought to find, describe, and assemble its leaves, twigs, and branches and illuminate the connections between all living things, past and present. In turn, that knowledge has nourished other sciences, from medicine and agriculture to engineering and climate studies.

"If you're interested in nature and you want to know about the fundamental questions," says GW biologist Guillermo Ortí, "then this is your road map to understand it."

More than 150 years of work has produced vast catalogs of the planet's biodiversity, limb by limb. At GW, where sketching the tree is the main focus of about one-third of the biology faculty and a core group from anthropology, the research spans the evolution of things big and small, from dinosaurs to single-celled organisms, plants to people.

GW biologists have led or co-led some of the many arms of a high-profile National Science Foundation project to map large branches, among a variety of other investigations. And even as they continue to fine-tune the resolution in sections of the tree, others among them are part of an ambitious plan to piece together the whole thing: a behemoth of some 2 million leaves representing every known animal, plant, fungus, and microbe species.

It won't be the cultural cold shower that was Mr. Darwin's theory. It will be, the researchers say, akin to the first glimpse of Earth from space: a chance to see all at once the fragile sum of existence, a fountainhead of new questions and, perhaps, some answers.

"A HUNDRED YEARS of received wisdom and hundreds of papers and articles." That's been the result, Alex Pyron says, of conventional knowledge on the oldest ancestor of lizards and snakes. That's what he's about to disrupt.

In research published in August, the GW biologist and a colleague suggest that the oldest ancestor of lizards and snakes probably gave birth to live young, rather than laying eggs.

That wouldn't be unheard of—around 20 percent of living lizards and snakes operate that way, Dr. Pyron says—but it reframes the way we look at their world. "It's a pretty major overturn of an accepted school of thought," he says.

The study required a framework for slogging through 170 million years of evolution, accounting for as many subgroups as possible. And Dr. Pyron had just the thing. Last year he and two colleagues published an evolutionary tree of lizards and snakes—together known as squamates—that covers 25 times the number of species as the next-largest genetic analysis of squamates.

A few years ago he did much the same for amphibians. And it's not an unfamiliar accomplishment around Bell Hall.

In 2012 researchers published the largest tree for the group of spiders called orb weavers, which make up one-third of all spiders, tracing them back to a 230-million-year-old common ancestor.

Last year GW researchers published the largest evolutionary study of "bony fish," a group that comprises the majority of the world's fish, and likewise for anomurans, a class of crustaceans that includes hermit crabs and king crabs. There was a comparative study of muscle evolution in primates, the first to be based on anatomical evidence, and the reporting of two new species that help fill in the fossil record: a 161 million-year-old dinosaur of the same ilk as *Tyrannosaurus rex*, and the closest relative to the group that gave rise, eventually, to modern crocodiles and alligators.

And in December, a GW-led paper in the journal *Nature* unveiled the most comprehensive view yet of the evolution of trees, shrubs, and other flowering plants, and used it to explore how land plants evolved to survive cold winters.

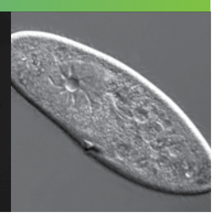
"THIS IS ONE OF THE MORE REVOLUTIONARY IDEAS IN SCIENCE IN THE LAST 200 YEARS, THAT POND SCUM TO KILLER WHALES CAN ALL BE PUT INTO THIS BIG TREE OF LIFE."

— DIANA LIPSCOMB, CHAIR OF GW'S BIOLOGICAL SCIENCES DEPARTMENT

ALEX PYRON
ROBERT F. GRIGGS ASSISTANT PROFESSOR OF BIOLOGY

FOCUS: *Snakes*

SPECIALTY: *Colubroids, the group that includes all the dangerously venomous snake species, as well as nonvenomous ones*



GUILLERMO ORTÍ
LOUIS WEINTRAUB PROFESSOR OF BIOLOGY

FOCUS: *Fish*

SPECIALTY: *Characiformes, a fish order that includes piranhas, an area of particular expertise*

AMY ZANNE
ASSISTANT PROFESSOR OF BIOLOGY

FOCUS: *Plants*

SPECIALTY: *Vascular plants, those adapted for life on land with specialized cells to move water, which include flowering plants.*

BERNARD WOOD
UNIVERSITY PROFESSOR OF HUMAN ORIGINS, DEPARTMENT OF ANTHROPOLOGY

FOCUS: *Primates*

SPECIALTY: *Hominins, the lineage that led to our own species,* Homo sapiens

DIANA LIPSCOMB
ROBERT L. WEINTRAUB CHAIR OF THE DEPARTMENT OF BIOLOGICAL SCIENCES, PROFESSOR OF BIOLOGY

FOCUS: *Protozoa*

SPECIALTY: *Ciliates, single-celled organisms with hair-like organs that propel them*

SNAKE: ©ISTOCK.COM/MARLEE90 / FISH: ©ISTOCK.COM/THARRISON / PLANT: ©ISTOCK.COM/MZURAWASKI
SKULL: NATURAL HISTORY MUSEUM, LONDON/SCIENCE SOURCE / PROTOZOA: ©ISTOCK.COM/MICRO_PHOTO

For two decades the university has been cultivating an expertise in systematics, or the classification of living things, and evolutionary history, nature's relentless tinkering that results in "endless forms most beautiful and most wonderful," as Mr. Darwin put it.

"This is one of the more revolutionary ideas in science in the last 200 years, that pond scum to killer whales can all be put into this big Tree of Life," says Diana Lipscomb, chair of the biological sciences department.

Dr. Lipscomb, who studies single-celled organisms, was the only systematist at the university when she arrived in the early 1980s, amidst what she describes as a decades-long lull for the field. "People didn't really understand how central this all was."

Now there's little mistaking it. In medicine and public health, evolutionary trees are used to identify diseases, such as the SARS outbreak in 2003, to help determine which flu strain to vaccinate against, to find ways to attack antibiotic-resistant bugs, and to prospect drugs from plants and animals. Venoms, for instance, are studied for their potential to treat conditions like heart attack, stroke, pain, and cancer. And trees can predict wider uses of antivenoms by pointing to animals that may be close cousins, despite looking like perfect strangers.

In agriculture, evolutionary trees are used to bolster crops and combat invasive species. They help engineers understand natural marvels, like adhesives that let geckos walk upside down on glass and the design of fins and wings.

"It's like man has a warehouse of

JAMES CLARK
RONALD WEINTRAUB PROFESSOR OF BIOLOGY

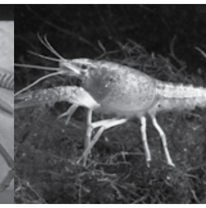
FOCUS: *Dinosaurs and Crocodylomorpha*

SPECIALTY: *Crocodilians, which burst into an array of forms during the Jurassic and Cretaceous periods, and include modern-day crocodiles, alligators, and gharials*

CATHERINE FORSTER
ASSOCIATE PROFESSOR OF BIOLOGY

FOCUS: *Dinosaurs*

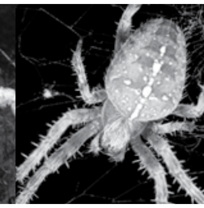
SPECIALTY: *Ornithopods, the group of bipedal herbivores that typically had horned beaks or duck bills, and large teeth for eating plants*



KEITH CRANDALL
DIRECTOR OF THE COMPUTATIONAL BIOLOGY INSTITUTE AND PROFESSOR OF BIOLOGY

FOCUS: *Crustaceans*

SPECIALTY: *Freshwater crayfish, lobster-like crustaceans that across some 600 species vary widely in color and size, ranging from under an inch long to more than 15 inches*



GUSTAVO HORMIGA
RUTH WEINTRAUB PROFESSOR OF BIOLOGY

FOCUS: *Spiders*

SPECIALTY: *Orb weavers, the spiders known originally for their classic wheel-and-spoke-shaped webs, though it's now known that their web-building can take many forms, and some don't produce webs at all*

things and we don't know 90 percent of what's in the warehouse," says Dr. Lipscomb. "How dumb is that?"

The systematics program at GW began to bud in the early 1990s. It was a practical leap, she says, based on the strength of what was already a century of collaboration between the Smithsonian Institution and GW's biology department and the limitations of its home, Bell Hall, which dates to 1935.

Graduate students already were taught by GW professors and Smithsonian National Museum of Natural History curators. Then in 1993 the program received a crucial boost when Professor Emeritus of Botany and three-time alumnus Robert Weintraub and his wife, Frances, set up an endowment that has grown to fund five professorships. (The systematics program is now named for Dr. Weintraub—as are a handful of new species.)

Around the same time, Dr. Lipscomb had been part of a small group of scientists lobbying to shift attention back to evolutionary studies. The effort helped spur the National Science Foundation's Assembling the Tree of Life program, which was launched in 2002 with Dr. Lipscomb serving a two-year stint at NSF as one of the program's administrators.

Geared toward large-scale, multi-institutional projects, the program started with a $17 million bang. It funded a handful of studies, including one on the connection between birds and their dinosaur relatives, led by GW paleontologist James Clark, and another on the evolutionary track of spiders, co-led by GW biologist Gustavo Hormiga.

Since then the NSF's program has invested millions more into dozens of tree studies, including two other GW-led trees: the one for "bony fish," the group that comprises most of the world's fish, and another for decapod crustaceans, which includes crabs, shrimp, crayfish, and lobsters.

Beyond those projects, the biology department continued to leverage its Smithsonian bond and endowed professorships to attract faculty members who have put the department on the map. They've forged collaborative relationships with New York's American Museum of Natural History, among other institutions, and established track records for winning funding for evolutionary studies year after year—in some cases now for two decades.

FOR MUCH OF THE HISTORY of evolutionary trees, and very much still today, connections have been made by comparing the physical characteristics of organisms. Over the past 50 years or so, genetic analysis has offered a deepening data gold mine for studying younger life-forms—those dating back perhaps several hundred thousand years, if their DNA has been preserved.

At its most basic level, DNA from two species is combed for

CROCODILE: ©ISTOCK.COM/GERRIT_DE_VRIES / DINOSAUR: JOHN KAPRIELIAN/SCIENCE SOURCE / CRUSTACEAN: ©ISTOCK.COM/OLGYSHA2008 / SPIDER: ©ISTOCK.COM/JSCALEV differences; the more differences they have, the farther apart they are from each other on the Tree of Life. Genetic differences can also help scientists estimate how long ago changes occurred.

The steady sprint of advances in sequencing technology and computing muscle have made possible massive studies that analyze thousands of genes—even whole genomes—or other biological markers across thousands of species.

These studies corroborate much of what had been surmised based on anatomy and fossils, but they also offer surprising insights.

Genetic analyses for the recent "bony fish" evolutionary tree turned up this tidbit: Although the warm-blooded tunas, mackerels, swordfish, and billfish, like the marlin, had been lumped together based on physical characteristics, researchers found that tunas and mackerels actually are more closely related to seahorses, and billfish and swordfish are closer to the Picasso-esque flatfishes, like flounder.

"They don't resemble each other at all," says GW postdoctoral researcher Ricardo Betancur, "but according to DNA, they are more closely related." Given that finding, it now appears that warm-bloodedness evolved independently at least twice among fish.

But DNA is also pointing to physical similarities that simply had gone unnoticed. Spider expert Gustavo Hormiga recently was studying an obscure group that was known to belong to the sprawling lineage of orb-weaving spiders, but scientists had "absolutely no clue" where they fit in, he says.

A genetic analysis suggested the closest relative, and once Dr. Hormiga got them side by side, the mystery became a head-slapper. "This makes a lot of sense," he says, "but nobody actually had that vision."

Despite the tidal wave of new genetic and anatomical data, resulting in thousands of new trees being published each year in scientific journals, the notion of a singular Tree of Life has remained simply a metaphor.

That could change this year. A research team is anticipating the release of a so-called first draft of the Tree of Life. The immense architecture, built by grafting together existing data, will include a spot for each of the roughly 2 million known species across more than 3 billion years of life.

"It will be a fundamentally different way to do systematics," says Keith Crandall, director of GW's Computational Biology Institute, who is one of the project's 11 leaders from 10 institutions.

The nearly $6 million project, called the Open Tree of Life, is one part of a three-pronged, $13 million initiative launched last year by the NSF that aims to produce an open-source tree and the analytical tools needed to explore it.

The task, Dr. Crandall says, is possible now because of advances in computing power and the recent work to bring the branches into better focus. The framework will include classification details for each species and, where available, evolutionary connections.

The researchers ultimately envision a tree that updates automatically as new data become available. But they're finding that the trees and genetic data found in studies overwhelmingly are not reusable, bound in formats like PDFs that can't be meshed with other data sets. Resolving that will require a shift in the field toward seeing the branching diagrams assembled for studies "as data, and not as a result," Dr. Crandall says.

The Open Tree of Life, however, also will bloom through crowdsourcing. The team is relying on scientists to upload their data, enticed by analytical tools capable of searching across the big picture and mining it for new perspectives and opportunities. Researchers will be able to see across life and through time at the emergence of specialized characteristics, booms and lulls in species formation, and how species historically have responded to climate change.

But, Dr. Crandall says, one of the most significant things the Tree of Life will show is precisely what isn't known; the pinholes and chasms in the collective knowledge.

And there are plenty—even in the number of species that are formally known to science.

It's "somewhere between 1.8 million and 2.2 million, depending on who you talk to," Dr. Crandall says. "That's part of the irony: Not only do we not know how many species are on Earth, we don't even have a reasonable handle on how many we've described."

And saying a species is known or described is relative: Diana Lipscomb, the biology chair, who studies singled-celled organisms, says she deals with "big chunks of tree" in which living species are called simply "Undescribed from the Atlantic Ocean," or "Undescribed from the Great Lakes."

Genes have been sequenced, she says, "but nobody knows what any of those things look like, what they're eating, how they're functioning."

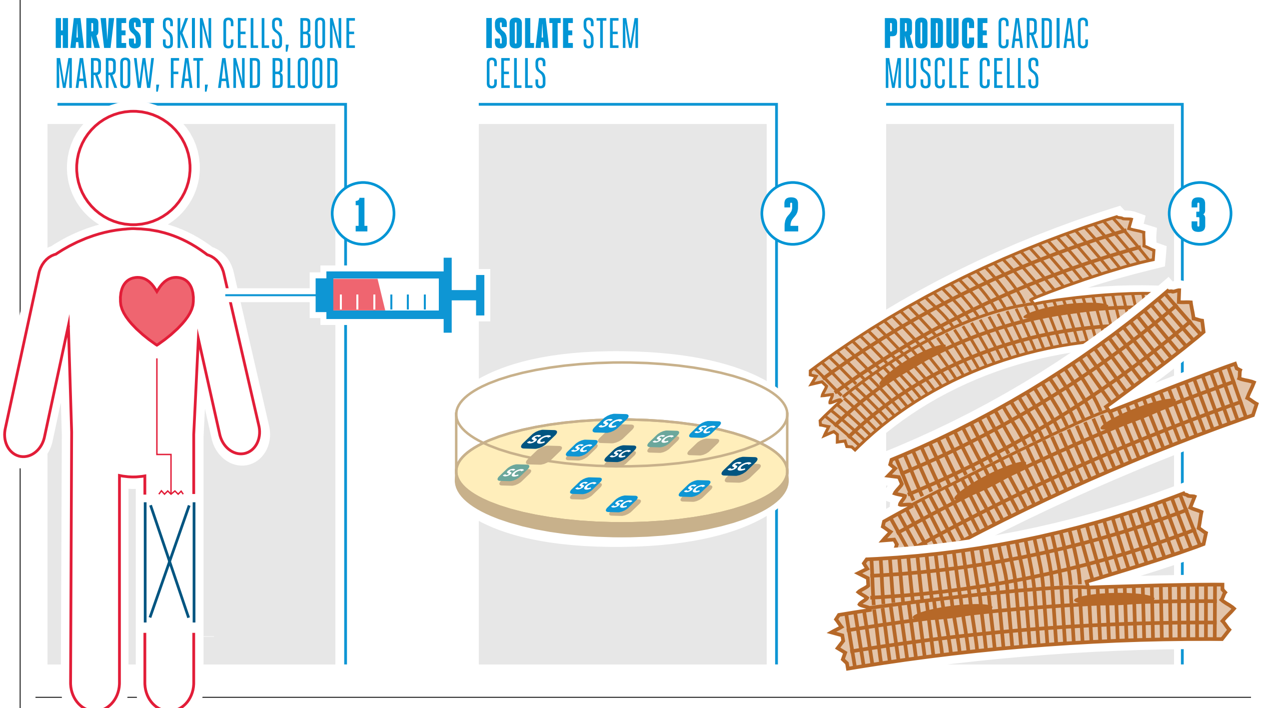
How much else is out there that may have no name at all? Guesses range from another million species to a hundred million.

The unknown weighs on Dr. Hormiga, the spider researcher, while collecting in remote locales, like a recent trip to an island 400 miles off the coast of Chile.

"Think of actually running through a library that's on fire," he says. "You're going to try to pull out as many books as possible before you get out of the building."

"The reality is that a lot of these places are going fast," he says. "The extinction rates are episodic. So it's not unthinkable that many of the places where I've collected will be gone, and the only evidence those species ever existed is what was deposited in a museum."

The trips, he says, are exhausting. "Because you know well there's not much time to sleep." GWR



A HEART IN THE RIGHT PLACE(S)

Narine Sarvazyan is engineering mini-hearts that can be put wherever the circulatory system could use an extra push
-By Ruth Steinhardt

Narine Sarvazyan

Narine Sarvazyan and her team were trying to create universal-donor stem cells—cell transplants that the immune system would be less likely to reject—when something else caught her eye.

Observing a clump of cardiac muscle cells, called myocytes, she noticed that they were affecting blood flow in nearby vessels.

"I thought: Why not just use these cells and wrap them around [a vein] and make a little pump?" says Dr. Sarvazyan, a professor of pharmacology and physiology in the School of Medicine and Health Sciences.

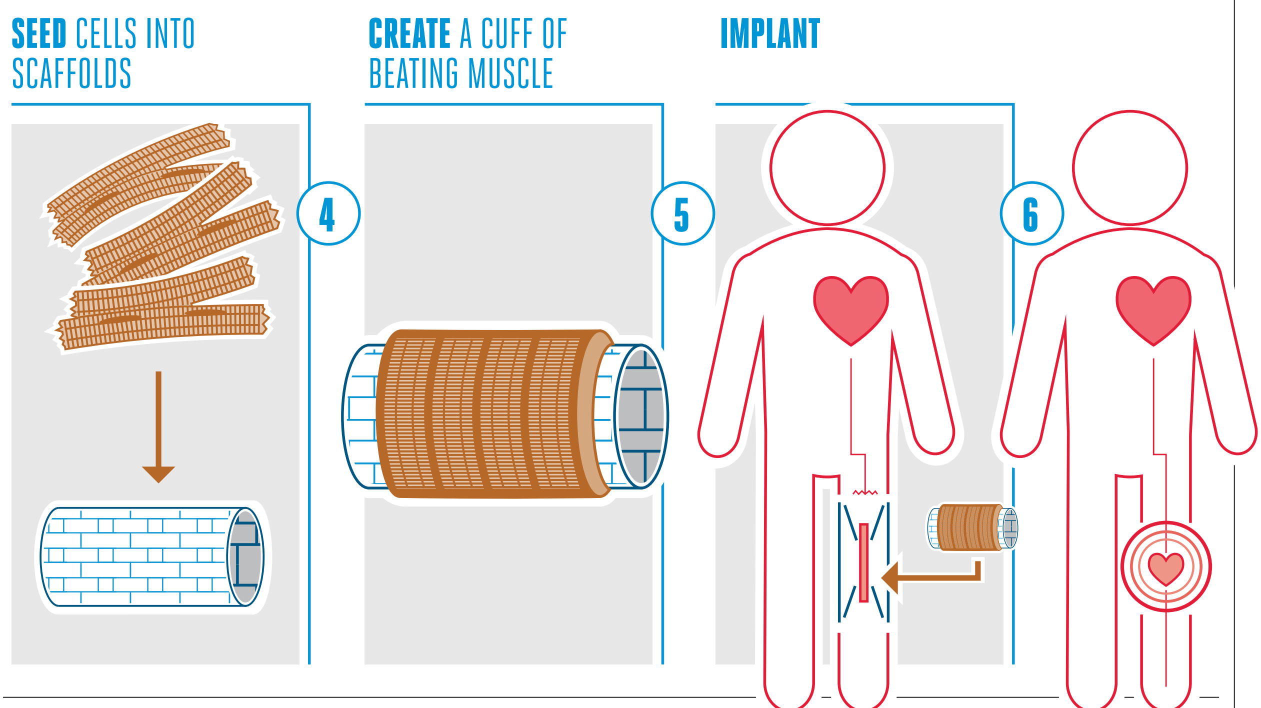
The pump, essentially, would be a miniature heart—the kind of extremely simple circulation-aiding organ of which some worms, for example, have several.

The human heart is usually sufficient to circulate blood through the body. In the lower extremities, the movement of skeletal muscles helps squeeze veins, and valves ensure that pressure pushes blood only one way—back to the heart.

As people age, however, those

SARVAZYAN: WILLIAM ATKINS

As people age and the valves inside their veins lose efficacy, mini-pumps made from patients' own heart cells could keep the blood flowing and ward off a slate of common health conditions.



GRAPHIC: COURTESY NARINE SARVAZYAN, JOHN MCGLASSON

valves often lose their efficacy and become one cause of blood pooling in the venous system. That pooling of the blood, called chronic venous insufficiency, can lead to varicose veins—which affect an estimated 25 percent of adults—as well as edema, ulcers, infections, or even amputations.

According to an article by Dr. Sarvazyan, published online in February in the *Journal of Cardiovascular Pharmacology and Therapeutics*, there are few treatment options at present, particularly when valves fail deep in the venous system.

Her idea could help treat the condition in a new way. Since groups of myocytes will spontaneously beat just as the heart does, tissue engineers could use a scaffold-like structure to build a rhythmically contracting piece of cardiac tissue from a patient's own stem cells. This self-beating muscle then could be wrapped around veins with dysfunctional valves to help push blood back to what Dr. Sarvazyan jokingly calls "the big heart."

The CardioVein technology, as it's been dubbed, is still in its early stages, but Dr. Sarvazyan and her team have built a prototype to test the concept and last year filed a provisional patent.

Researchers elsewhere, working on "big heart" tissue repair, have already successfully grafted small pieces of cardiac muscle to live animals, where it became vascularized and continued to beat for months, she says.

"All the individual steps of this process already have been shown by ourselves or others," she says. "So there are many indirect indications that [the concept] should work."

The next step is to measure whether the cuff, wrapped around a vein, could produce sufficient pressure to aid circulation in a living animal. This summer Dr. Sarvazyan and her team will work on strengthening the cuffs and measuring the pressure and flow they are capable of producing. With sufficient funding, she says, they could begin testing in live animals within the year.

Until then, Dr. Sarvazyan has to divide her focus among multiple projects—including the stem cell research that first sparked her imagination. But the mini-heart idea might be the most revolutionary.

"It's really exciting in its simplicity," she says. GWR

Let's Find Solutions for Autism "AND" Make History

More children will be diagnosed with autism spectrum disorders in the United States this year than pediatric AIDS, juvenile diabetes and childhood cancer—*combined*. Currently, there are an estimated 3 million individuals—one child in 68 children—who have autism in the U.S.; in the next decade, 500,000 of those individuals will become adults. The country is unprepared to effectively incorporate these individuals into society. With no definitive plan for adults with autism, the time to act is *now*. The GW **AND** Initiative is focusing on the development, transitional and comprehensive needs of adolescents and adults with autism. Your support will empower our efforts to effect change.

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