May 2021 • Vol. 30, No. 5
aps.org/apsnews

APS NEWS

A PUBLICATION OF THE AMERICAN PHYSICAL SOCIETY

GOVERNMENT AFFAIRS

APS Honors Members for Outstanding Science Policy Advocacy

BY TAWANDA W. JOHNSON

APS Government Affairs (APS GA) is proud to announce that 12 Society members have been selected as Five Sigma Physicist awardees for their outstanding advocacy work that included taking multiple actions during the past year and maintaining communication with APS GA staff.

This year's awardees participated in various iniatives centered on contacting Congress and the Executive Branch to help advance APS's science policy priorities, including: ensuring the US scientific enterprise fully recovers from the pandemic, supporting visa and immigration policies that attract and retain talented international students to the United States, addressing the helium crisis, and ending sexual harassment in STEM.

Tracy Edwards, a PhD student in the Department of Physics and Astronomy at Michigan State University, said she was "honored" to receive the Five Sigma Physicist Award. Her work involved advocating for nuclear threat reduction during a meeting with staff representing US Sen. Gary Peters (D-MI). Paul Campbell and Andrea Richard also attended the meeting with Edwards. And, as members of the Physicists Coalition for Nuclear Threat Reduction, all of them sent letters to Congress to support an extension of the New START Treaty and to oppose funding for resuming explosive nuclear testing. The treaty covers a limit on nuclear arms between the United States and Russia. In January, President Joe Biden and Russian President Vladimir V. Putin agreed to a five-year extension of the treaty—a move supported by APS in its recent Board Statement.

"As both a scientist and citizen, it was important for me to join the Physicists Coalition for Nuclear Threat Reduction to advocate for the safety and well-being of our nation," said Edwards, adding "I intend to pursue a career in nuclear policy, working alongside other physicists with the same interest to build my foundation of knowledge and experience in the field."

Mark Haynes and Stephen Schiff were also awarded the Five Sigma Physicist accolade for their work in advocating for the extension of New START and opposing funding for explosive nuclear testing during a meeting with staff representing US Sen. Tim Kaine (D-VA).

"I am pleased that this award exists because of the importance of advocacy to the science community," said Haynes, Retired President of Concordia Power and member of the Physicists Coalition for Nuclear Threat Reduction.

FIVE SIGMA CONTINUED ON PAGE 4

INDUSTRIAL PHYSICS

What is it Like Being a Data Scientist?

Data science is one of the fastest-growing career fields and is expected to increase by more than 30 percent during the next 10 years, according to the US Bureau of Labor Statistics. APS Director of Industrial Engagement Dan Pisano recently interviewed Jie Ren, a Data Scientist in the Global Digital Analytics & Technology Group for Merck & Co., to gain insight into this exciting career that bodes well for scientists with physics backgrounds.

Jie Ren

Dan: Where do you work and why did you choose to pursue a career there?

Jie: I work at Merck & Co., Inc., a US-based biopharmaceutical company. I am in the Global Digital Analytics & Technology group; my job focuses on integrating remote monitoring technologies for clinical trial use and developing digital biomarkers for drug development. I've always been interested in pushing the real-world application of my physics background. Merck, as a big player in the pharmaceutical sector, was a great choice for me to achieve this goal.

Dan: Did you start out as a data scientist? What other positions did you have?

Jie: I did not start out as a data scientist. Instead, with my soft matter research background, I joined Merck as a material scientist and started in the formulation development function. From there,

DATA SCIENCE CONTINUED ON PAGE 6

MEETINGS

2021 Kavli Foundation Special Symposium Tackles the Frontiers of Computation

BY LEAH POFFENBERGER

After its cancelation last year due to the coronavirus pandemic, the March Meeting came back strong in 2021, with a new online format drawing in a record number of March attendees—over 13,000 registrants. While many aspects of the meeting might have differed from a traditional March Meeting, the Kavli Foundation Special Symposium returned as a highlight of the meeting, featuring distinguished researchers in the fields of quantum computing and machine learning.

The five speakers on hand to share their expertise in these fields were: Patrick Francis Riley (Google Accelerated Science), Roger Melko (University of Waterloo, Perimeter Institute), Michelle Girvan (University of Maryland, College Park), Eun-Ah Kim (Cornell University), and John P. Preskill (Caltech).

After a brief introduction from APS CEO Jonathan Bagger, who highlighted the "potential of [machine learning and quantum computing] to transform physics," Riley kicked off the Kavli symposium. In his talk "Vignettes of Machine Learning in the Natural Sciences," Riley detailed on-going projects at Google Accelerated Science to harness machine learning technology. First, he described the use of machine learning as a tool for small molecule drug discovery, allowing researchers to search for potential therapeutic molecules on a previously impossible scale. He also presented another project that seeks to integrate computational physics and machine learning by using differentiable programming to tackle physics problems like solving Schrödinger's equation.

Next, Melko gave a talk on "Machine Learning and the Complexity of Quantum Simulation," where he discussed the use of generative models from machine learning to enhance quantum simulations. Melko also discussed two forms of quantum simulation—Hamiltonian-driven and data-driven—along with the difficulties that surround each method. With data-driven generative modeling, Melko says we are

KAVLI CONTINUED ON PAGE 3

MARCH MEETING

New Laser Testing Approach Detects Coronavirus in Minutes

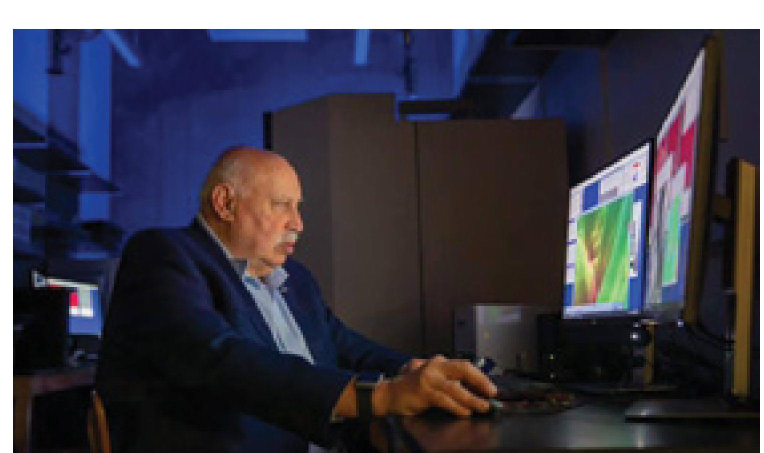
BY LEAH POFFENBERGER

Effective control of the spread of viruses like SARS-CoV-2, the virus responsible for the COVID-19 pandemic, relies on three Ts: testing, tracing, and treatment. Testing for coronavirus infection remains important, especially as many areas in the United States are starting to re-open schools and loosen restrictions designed to slow its spread. However, the main testing methods for COVID-19 are often hindered by cost and speed, with some tests trading accuracy to get faster results.

At the 2021 APS March Meeting, Miguel José Yacamán, a professor in the Applied Physics and Materials Science Department at Northern Arizona University (NAU), described a new method of virus detection using laser spectroscopy to deliver fast, cost effective results. Yacamán has been applying a type of Raman spectroscopy, a tool with uses ranging from solid-state physics to breast cancer diagnosis, to detect the SARS-CoV-2 virus in a saliva sample in minutes.

"The biggest strength of this method is its portable application: You don't have to take saliva to a lab for testing," said Yacamán. "We can have results from a test in about five minutes ... which

CORONAVIRUS CONTINUED ON PAGE 6



Researchers in the lab of Miguel José Yacamán at Northern Arizona University are studying a way to quickly detect the virus that causes COVID.
CREDIT: NORTHERN ARIZONA UNIVERSITY

OBITUARY

Neil Ashcroft 1938-2021

BY DANIEL GARISTO

Neil Ashcroft, a theorist who paved the way for high-temperature hydrogen superconductors and was renowned for his commitment to educating the next generation of physicists, died on March 15 in Ithaca. He was 82.

For his work, Ashcroft collected honors including a Guggenheim Fellowship and the Bridgman Award for high pressure physics. In addition to his leadership positions, Ashcroft was an honorary fellow of the Royal Society of New Zealand, a foreign member of the Russian Academy of Sciences, and elected to the National Academy of Sciences. He was a fellow of APS.

"He could well have shared a future Nobel Prize on high-temperature superconductivity," said N. David Mermin, his longtime colleague at Cornell University. "That was really uniquely Neil's way of thinking about things—I don't think anybody else had thought about what hydrogen would be like if the hydrogen nuclei were extremely dense."

Ashcroft had a fitting mantra to describe many of his research interests: "Whatever it is, squeeze it." In 1968, he published a paper in *Physical Review Letters* simply titled "Metallic Hydrogen: A High-Temperature Superconductor?" Four decades later, he made another seminal contribution to the field by proposing chemical precompression in a hydrogen alloy—the other element would squeeze hydrogen into a lattice even before external force was applied. His work formed the backbone of research that, last year, led to the first ever room-temperature superconductor: a hydrogen alloy under 2.6 million atmospheres of pressure.

"Theory, experiment, everything that we all do—it's his ideas that we are putting into action," said Ranga Dias, a physicist at the University of Rochester who led the team that created the room-temperature superconductor. "It's a big loss to our field."

Neil William Ashcroft was born in London in 1938, but after World War II ended, his family emigrated to New Zealand, where he was raised by his mother. Ashcroft got his bachelor's and master's degrees at what was then Victoria College of the University of New Zealand, before he went back to Cambridge for his PhD under John Ziman, working on the Fermi surfaces of

Neil Ashcroft
CREDIT: CORNELL UNIVERSITY

metals—the aesthetically pleasing shapes that show which electron orbitals are filled or unfilled at absolute zero. By 1964, Ashcroft made his way to Cornell, where he remained for the rest of his career. But he never forgot his roots in New Zealand.

"Once a year Neil would turn up and he'd usually stay for about a month over the New Zealand summer with his wife and to catch up with friends," said Nicola Gaston, a physicist at the University of Auckland. "He was so self-effacing and humble about who he was that there are a lot of people who probably don't realize how significant a role he played behind the scenes."

In addition to his work guiding science in New Zealand, Ashcroft organized numerous conferences and served as a mentor to many students—even those who he didn't supervise. But his greatest impact on physics came through the textbook he coauthored with Mermin, *Solid State Physics*, an encyclopedic tome simply known as *Ashcroft and Mermin*. Published in 1976 after 7 years of work and never revised, it remains the gold standard for condensed matter texts even half a century later, despite massive advances in the field.

"Traditional solid state physics books always began—and still do—with crystallography," said Mermin. "Which is a very boring subject and quite technical, and one of the good things about the book was getting right into the physics."

The first two chapters in *Ashcroft and Mermin* instead cover the Drude and Sommerfeld theories of metals.

ASHCROFT CONTINUED ON PAGE 5

THIS MONTH IN

Physics History

May 1931: Publication of the creation of the first aerogel

The ultralight, porous, synthetic materials known as aerogels are 99.8 percent air, earning them the nickname "frozen smoke." Until 2012, silica aerogel held the Guinness World Record for lowest-density solid. Their unusual properties make them ideal for a variety of scientific and industrial applications, such as experiments to capture cosmic dust in space, as thermal insulation on NASA's Mars rovers, and as radiators in certain particle detectors. The man who first created them was a chemist named Samuel Kistler.

Born in 1900 in the small cattle town of Cedarville, California, Kistler's father was a shopkeeper. Young Sam dreamed of breaking wild horses and being a cowboy, but when he was 12, his father sold his store and the family moved to Santa Rosa. In high school, he fell in love with chemistry, taking extra college classes in the subject in addition to his high school curricula.

When he first started at the College of the Pacific in 1917, Kistler hoped to learn the cello, and eventually earn an agricultural degree. Those plans changed three years later, when he transferred to Stanford to complete his bachelor's degree in chemistry. After graduating, he went to work at Standard Oil Company in California, returning to the College of the Pacific a year later to teach chemistry. Apart from one year abroad, he stayed there until 1931, when he moved to the University of Illinois.

It's not clear exactly when Kistler succeeded in making his first aerogel, or even where: The College of the Pacific, which had limited experimental facilities, or Stanford University, where Kistler earned his PhD. His master's thesis was on the crystallization of amino acids from supercritical fluids, and he published several papers in the late 1920s on using wet gels as ultra-filters.

Legend has it that he was originally inspired by a bet with a fellow scientist named Charles Learned over whether it was possible to replace the liquid inside a jelly jar without causing shrinkage. We do know that aerogels were the focus of his research by the time he got to Illinois, and that Kistler published the results of his aerogel experiments in a May 16, 1931, paper in *Nature*. He used a process known as supercritical drying to make them, forcing the liquid into a supercritical fluid state by increasing the temperature and pressure. He then reduced the pressure, which vaporized and removed the liquid inside, leaving just the porous solid in place.

Yet aerogels were largely forgotten for the next three decades. The process to make them was

A flower suspended over a flame is thermally protected by a piece of aerogel. CREDIT: NASA.GOV

laborious and expensive, as well as potentially explosive. It also required toxic compounds. As for their properties, aerogels were cloudy rather than transparent, and while they showed good thermal resistance, it wasn't quite good enough in early aerogels for commercialization purposes.

So Kistler moved on, leaving the University of Illinois in 1935, first working at Norton Company to research abrasive grinding compounds, moving up to become director of research. Most of his patents date from period. He was also part of the company's effort to synthesize diamonds, although Norton passed on commercializing the breakthrough, persuading General Electric to do so instead. Kistler also invented a scratch-resistant polymer for eyeglasses.

Kistler worked with Monsanto in the early 1940s to develop silica aerogel products for use as flattening agents in paints and varnishes; as a thickening agent in the jelly used to make napalm bombs and salves for sheep; and as an ingredient to make silicone rubber. Perhaps because it was so expensive to make, and increased competition from other silica and thermal insulation products, the company discontinued its Santocel line of products around 1970.

Kistler moved to the University of Utah in 1952 to become dean of engineering, where he continued to teach and conduct research until he retired. He was a strong advocate for scientific education and its importance to society. "Recognize that technology has no morals," he told graduating engineers in 1965. "It serves evil

HISTORY CONTINUED ON PAGE 6

APS NEWS

Series II, Vol. 30, No. 5
May 2021
© 2021 American Physical Society

Editor.................**David Voss**
Staff Science Writer.................**Leah Poffenberger**
Contributing Correspondents.................**Sophia Chen and Alaina G. Levine**
Design and Production.................**Meghan White**

APS News (ISSN: 1058-8132) is published monthly, except for a combined July-August issue, 11 times per year, by the American Physical Society, One Physics Ellipse, College Park, MD 20740-3844, (301) 209-3200. It contains news of the Society and of its Divisions, Topical Groups, Sections, and Forums; advance information on meetings of the Society; and reports to the Society by its committees and task forces, as well as opinions.

Letters to the editor are welcomed from the membership. Letters must be signed and should include an address and daytime telephone number. APS reserves the right to select and to edit for length and clarity. All correspondence regarding *APS News* should be directed to: Editor, *APS News*, One Physics Ellipse, College Park, MD 20740-3844, Email: letters@aps.org.

Subscriptions: *APS News* is an on-membership publication delivered by Periodical Mail Postage Paid at College Park, MD and at additional mailing offices.

For address changes, please send both the old and new addresses, and, if possible, include a mailing label from a recent issue. Changes can be emailed to membership@aps.org. **Postmaster:** Send address changes to *APS News*, Membership Department, American Physical Society, One Physics Ellipse, College Park, MD 20740-3844.

Coden: ANWSEN ISSN: 1058-8132

MEETINGS

2021 PhysTEC Conference: Teacher Training Online

BY LEAH POFFENBERGER

The 2020 PhysTEC conference, held in Denver last March, had the unique distinction of being the last in-person APS meeting. This year, the 2021 PhysTEC Conference went online, bringing together over 100 attendees from PhysTEC sites across the country. The two-day meeting, held on March 5 and 6, was packed with sessions on a variety of topics affecting physics teacher education, as well as opportunities for attendees to connect and share their own ideas and experiences.

PhysTEC, a partnership between APS and the American Association of Physics Teachers (AAPT), began in 2001, with a goal of addressing a critical shortage of qualified physics teachers in the United States. Over 300 institutions across the US have joined PhysTEC, displaying a dedication to promoting physics teacher preparedness. The PhysTEC conference represents an important opportunity to bring together representatives from PhysTEC sites to discuss the state of physics teacher education, learn about resources and techniques for improving education programs, and provide feedback on the state of the PhysTEC program.

"We were able to put together a really good program," says Annelise Roti Roti, PhysTEC Coordinator. "Everyone who came to speak was nothing short of exceptional and really helped the whole conference be as good as it was."

Highlights of the 2021 PhysTEC conference included two plenary panels—one on strategies for inclusive teaching and another on new online teaching strategies for physics education—the PhysTEC Teacher of the Year Award Presentation, and breakout sessions on a number of topics, from NSF funding opportunities to creating inclusive culture with learning assistants.

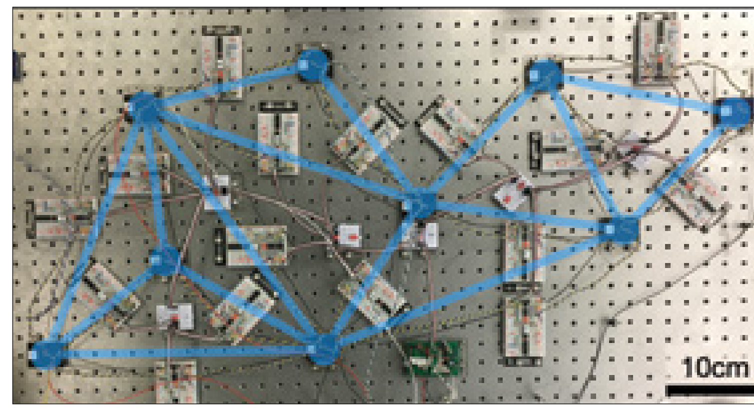
"Many people said how great [the conference] was and how much they stuck around for discussions, which is pretty remarkable for an online conference when everyone is tired of being online," said David

PHYSTEC CONTINUED ON PAGE 5

MEETINGS

Programming Matter to do a Computer's Job

BY SOPHIA CHEN



Researchers at the University of Pennsylvania have developed an electrical circuit that learned to identify different kinds of iris flowers. CREDIT: SAM DILLAVOU

Most computers perform tasks by propagating electronic signals on silicon chips. But researchers are currently pursuing different computing frameworks, some inspired by biological systems, that could offer advantages in robotics or biomedical applications. Many of these new frameworks make use of programmable matter—materials designed to change their properties in response to varied inputs. This year's virtual APS March Meeting included several talks on developments in programmable matter.

The term "programmable matter" was coined in 1991 by physicist Norman Margolus and computer scientist Tommaso Toffoli. Margolus and Toffoli used the phrase to describe CAM-8, a cellular automata machine they'd designed that can be thought of as an array of pixels. Algorithms for this machine made use of the pixels' spatial arrangement, and each cell or pixel had specific rules for interacting with the others. Research suggested this type of machine could efficiently simulate fluid flow and chemical reactions.

Over the last three decades, the term has now evolved to describe materials that can change their physical properties—shape, elasticity, or electrical properties, to name a few—based on prearranged triggers. One 2015 demonstration from the Massachusetts Institute of Technology involved a self-assembling origami robot that could also self-destruct: a sheet that folded up into a tiny shape to move around, carry loads, and dissolve itself in acetone.

At the 2021 March Meeting, postdoctoral researcher Sam Dillavou of the University of Pennsylvania described an electrical circuit that "learned" to adjust its own resistance to produce a desired voltage output without top-down instruction.

The system, which relied on a theoretical framework by postdoctoral researcher Menachem Stern of University of Pennsylvania, used two identical circuits with variable resistors that were both set to the same initial values. Dillavou applied the same voltage to each circuit but biased one of them to produce a voltage output closer to the desired value. By comparing the power dissipation of the two circuits, both circuits adjust their resistors to produce the desired voltage.

Dillavou demonstrated that this circuit could perform a simple machine learning task using a historical dataset of measurements of 150 iris flowers. Given four dimensional measurements of an iris, the circuit learned to produce a voltage that indicated which of three types of iris the measurements came from. The circuit first learned the correct classification for 30 iris

MATTER CONTINUED ON PAGE 5

GOVERNMENT AFFAIRS

Commentary: Staying the Course in Science Policy Advocacy during COVID

BY RAJU PRASAD GHIMIRE

Last year proved to be an extremely difficult year for people around the world for myriad reasons, including a global health pandemic that has negatively impacted millions of lives and led to a struggling economy, as well as racial unrest following the death of George Floyd and other Black Americans. And sadly, anti-Asian racist crimes are also on the rise.

These are tough, but necessary issues to deal with, and I understand that they will not be immediately solved. Still, I choose to remain hopeful about the future. And one way I plan to make a difference is by remaining active in science policy to enable my voice and many others to be heard on crucial issues that are important to the physics community.

In 2017, I got involved in science policy by volunteering with the APS Forum for Early Career Scientists (FECS). As a secretary/treasurer of FECS, I participated in both the APS Annual Leadership Meeting and APS Congressional Visit Day for two consecutive years. During those events, I learned that members of Congress are eager to hear from scientists whose technical expertise plays important roles in shaping federal policy. In 2019, I joined the APS Forum on Graduate Student Affairs (FGSA), serving as secretary and mainly focusing on helping international students.

Specifically, that fall, I was instrumental in working with APS Government Affairs (APS GA) and APS International Affairs on a survey of international students' concerns regarding visa and immigration policies. The survey revealed that 32% of international students who chose not to come to the US believe the country is "unwelcoming to foreigners." Unfortunately, those revelations don't bode well for many academic institutions that are confronting decreased enrollments among international students. I was elated, however, to help support APS GA's efforts to advocate for international students by writing to my members of Congress in support of visa and immigration policy changes designed to help the United States attract and retain talented international STEM students.

Besides grappling with policies that didn't help them, international students, just like the rest of the world, had to deal with COVID-19, which sent their lives into a tailspin. Students experienced disruptions to research programs, struggled financially to make ends meet, and confronted physical and mental health crises. To do my part to help with these issues, I was eager to lend my voice to a campaign that APS GA sponsored to enable graduate students and postdocs to continue to receive compensation from federal grants during the pandemic. I'm also grateful to my advisor Mehran Tehrani for his unending support throughout such a difficult time.

Although the world continues to deal with the pandemic, new

Raju Prasad Ghimire

vaccines offer hope—a virtue that attracted me to America. Hope was also instilled within me as I grew up in the small town of Damak, Nepal: I am a proud, first-generation college student. But I don't just care about my own success. I want everyone to succeed, and that's why I started an international high school in my hometown with a focus on scientific education. In 2015, I came to America with the hope of broadening my knowledge by obtaining a PhD in science and engineering.

Three years later, I earned my master's degree in electrical engineering at South Dakota State University. Currently, I'm working on my PhD in nanoscience and microsystem engineering through a collaboration with the University

POLICY CONTINUED ON PAGE 5

KAVLI CONTINUED FROM PAGE 1

"entering a new era" of simulation, which could lead to discoveries in condensed matter and quantum information. Generative modeling has the potential to increase our understanding of the complexity of quantum simulation.

Girvan followed up, with a talk on more uses for machine learning technology titled "Opening the black box: Improving knowledge-free machine learning with knowledge-based models." In her work, Girvan combines artificial intelligence and machine learning approaches with mathematical modeling, with the goal of predicting complex, chaotic systems such as the weather, and stochastic systems with randomness, such as the stock market. Using a subset of machine learning called reservoir computing and incorporating "knowledge"—such as standard rules of physics—into a hybrid scheme, Girvan showed good predictions of complex weather systems.

Kim discussed ways to harness machine learning for the understanding of quantum emergence. In order to develop theoretical insight from complex experimental data, or to make predictions based on this theoretical insight, Kim has worked with several groups using machine learning tools in various ways, such as hypothesis testing to better understand quantum matter. Approaches like neural networks can solve problems related to a huge volume of data available in the study of quantum emergence. According to Kim, different types of machine learning can provide new insights into complex discoveries or accelerate discovery by processing huge amounts of data in a short period of time.

To close the Kavli Symposium, Preskill provided an overview of the field of quantum information science in his talk "Quantum Computing: current status and future prospects." He discussed the potential strengths of quantum computing, the difficulties involved with developing quantum systems, and current quantum devices that are producing interesting results. According to Preskill, the field is currently in the noisy intermediate-scale quantum (NISQ) era, which is suited for scientific exploration, but experiences limited computational power due to noise limits. Quantum researchers are now setting their sights on moving from NISQ to fault-tolerant quantum computers, which will exponentially scale up the number of physical qubits but will also have direct applications to physics, chemistry, materials science, and more.

The Kavli Special Symposium is made possible by The Kavli Foundation. To view the symposium, visit youtube.com/watch?v=oEpW1dfq5Ws.

FIVE SIGMA CONTINUED FROM PAGE 1

He added, "This past year, I was involved in important congressional advocacy on behalf of the coalition, and perhaps more significantly, took on the responsibility of building a bridge between the coalition and the American Nuclear Society (i.e. primarily the nuclear energy community). That work resulted in a well-attended ANS-sponsored webinar on the history and lingering threat of nuclear weapons pegged to the occasion of the 50th anniversary of the nonproliferation."

Michael Sobel, Pawel Kozlowski, and Grant Meadors, also members of the coalition, received the Five Sigma Physicist Award for their work in supporting similar advocacy initiatives that were conveyed to staff representing US Sen. Kirsten Gillibrand (D-NY) and US Sen. Martin Heinrich (D-NM).

APS members John Chernega, Laurie McNeil, and Juan Gallardo participated in numerous grassroots campaigns last year. Their actions included advocating for: COVID-19 relief for researchers, ending sexual harassment in STEM, and protecting the Optional Practical Training Program. Chernega took 22 actions during nine campaigns. Gallardo took 22 actions during eight campaigns, and McNeil took 16 actions during eight campaigns.

McNeil, the Bernard Gray Distinguished Professor in the Department of Physics & Astronomy at the University of North Carolina at Chapel Hill, was "surprised" to find out that she had been selected for the Five Sigma Physicist Award.

"It seems to me that I have just been doing what every APS member should do in response to requests from (APS GA) to help physicists' voices be heard in the legislative and policymaking process," she said.

McNeil recalled sending a letter to Congress supporting international students who faced having their F-1 visas revoked if they did not take in-person classes during the pandemic.

"At the time, I had two foreign nationals graduate, leave my lab, and go to jobs where they are now making important contributions to our country's scientific and technological enterprise. I wanted to make sure that policymakers understood how vital these kinds of students are to our nation's success," McNeil explained.

She pointed out that every APS member can make difference in advocacy efforts "simply by responding to requests to send messages to Congress and federal agencies."

"The benefit from our communal effort far outweighs the very minor cost in time, especially since APS staff provide everything one needs to communicate effectively," McNeil said.

"I feel highly honored to be recognized for advocacy work," said APS Past President Phil Bucksbaum, who was active in numerous initiatives last year. "I also think it is important that APS has this kind of recognition because advocacy for physics helps the whole science research community."

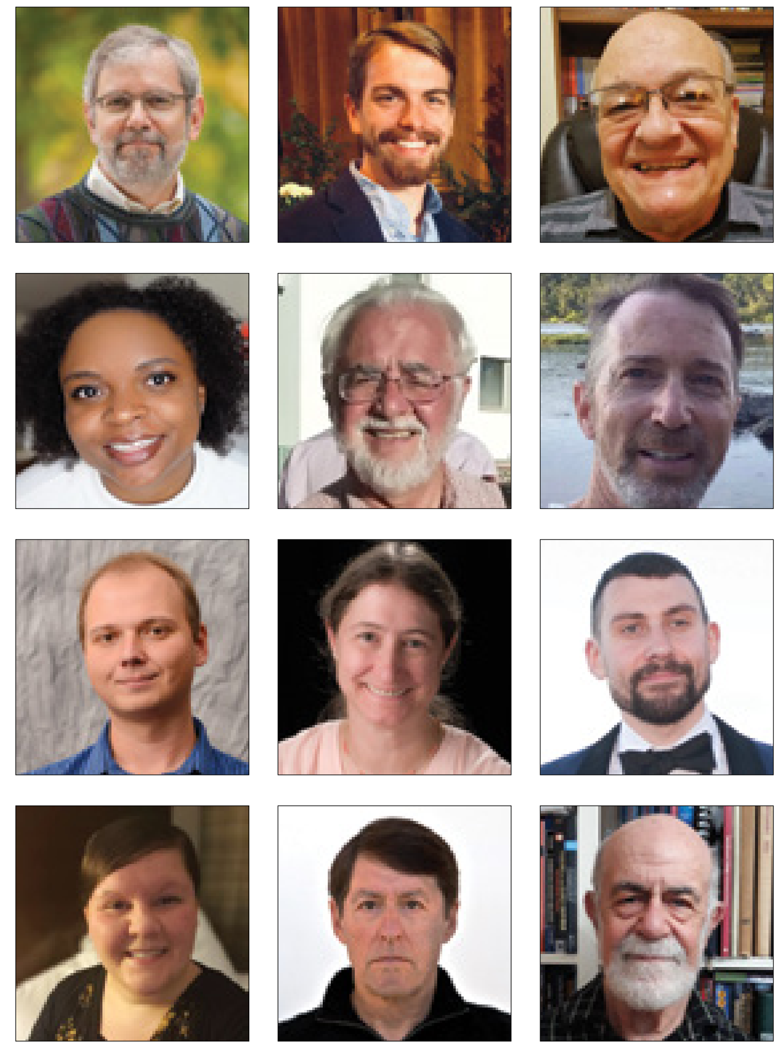
Bucksbaum was instrumental in pushing back against the Trump Administration's order that would have forced international students currently living in the United States to return to their home countries if they could not attend in-person classes during the pandemic.

"This order would have disrupted the educational paths of hundreds of physics students and the research of many of our members. Harvard and MIT sued for an injunction, and over a single weekend, we quickly drafted our own amicus brief in support, and then organized 16 other societies, including AAAS and OSA to join us," recalled Bucksbaum, who is the Marguerite Blake Wilbur Professor in Natural Science at Stanford University, with appointments in physics, applied physics, and photon science at SLAC.

He continued, "Briefs were also submitted by hundreds of colleges and universities, and the net result was that the government capitulated entirely. I was watching online in the Zoom spectator gallery of the federal district courtroom in Boston when the government abandoned the case, and it was an exciting and memorable moment. This shows the importance of an organization to act quickly. It also shows that such actions by individual citizens working together can truly make a difference. Here was APS at its finest, and I treasure the feeling of pride in the organization that I felt at that moment."

APS GA is thrilled to honor Society members who have gone the extra mile to let their voices be heard on matters impacting the US scientific enterprise.

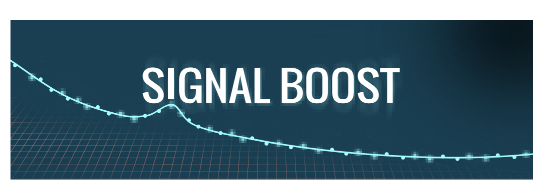
"We greatly appreciate the time that thousands of APS members take out of their busy schedules each year to add their voices to help advance policies that are important to the physics community," said Mark Elsesser, Director of APS GA. "Our Five Sigma Physicist awardees are exemplars of science advocacy, and we're elated to be able to highlight their efforts with this award."



(top left to bottom right) Phil Bucksbaum, Paul Campbell, John Chernega, Tracy Edwards, Juan Gallardo, Mark Haynes, Pawel Kozlowski, Laurie McNeil, Grant Meadors, Andrea Richard, Stephen Schiff, and Michael Sobel

To learn more about APS GA's advocacy campaigns and take action on them, check out its Action Center.

The author is APS Senior Press Secretary in the Office of External Affairs.



Signal Boost is a monthly email video newsletter alerting APS members to policy issues and identifying opportunities to get involved. Past issues are available at go.aps.org/2nr298D. **Join Our Mailing List: visit the sign-up page at go.aps.org/2nqGtJP.**

FYI: SCIENCE POLICY NEWS FROM AIP

Key Science Budget Gavels Change Hands in Congress

BY ADRIA SCHWARBER

The changeover in Congress following last year's election has brought new faces to some key roles on the House and Senate Appropriations Committees, which are responsible for drafting the federal discretionary budget. The two committees each divide the work among 12 mirror-image subcommittees, about half of which are together responsible for the lion's share of science funding.

The most notable change that has occurred is that the Senate panels are now controlled by Democrats for the first time in six years, and the party has taken unified control over the congressional agenda for the first time in a decade.

With the power shift in the Senate, Sen. Dianne Feinstein (D-CA) has moved from ranking member to chair of the Energy-Water Subcommittee, which handles the Department of Energy's budget. Sen. John Kennedy (R-LA) is the subcommittee's new top Republican, replacing Sen. Lamar Alexander (R-TN), a leading advocate for DOE's research programs and national labs who retired in January. DOE does not have a large research footprint in Kennedy's state, in contrast to those of Alexander and Feinstein.

Sen. Jon Tester (D-MT) has replaced Sen. Dick Durbin (D-IL) as top Democrat on the Defense Subcommittee, which is responsible for the Defense Department's expansive research, development, test, and evaluation portfolio. Sen. Richard Shelby (R-AL) returns as the top Republican on both the subcommittee and the full committee, though he has announced he will not seek reelection in 2022.

Sen. Jeff Merkley (D-OR) is the new chair of the Interior-Environment Subcommittee, which is responsible for the budgets of the Environmental Protection Agency and US Geological Survey, taking over as top Democrat from retired Sen. Tom Udall (D-NM). Sen. Lisa Murkowski (R-AK) returns as the subcommittee's top Republican.

Aside from the switchover in party control, leadership is unchanged for the Senate subcommittees that have jurisdiction over the budgets of the National Institutes of Health, NASA, National Science Foundation, National Oceanic and Atmospheric Administration, and National Institute of Standards and Technology.

Both Sens. Jeanne Shaheen (D-NH) and Jerry Moran (R-KS) return to lead the Commerce-Justice-Science Subcommittee, which is responsible for NASA, NSF, NOAA, and NIST. Likewise, Sen. Patty Murray (D-WA) and Sen. Roy Blunt (R-MO) are holding

FYI CONTINUED ON PAGE 6

MATTER CONTINUED FROM PAGE 3

examples. It could then classify the other 120 flowers with 95 percent accuracy. In effect, the circuit performed "supervised learning"—a common method in artificial intelligence today in which a computer learns to identify a cat after being shown many labeled photos of cats.

In addition, the circuit still worked when they damaged it. Dillavou cut wires in the circuit, and after additional training, it was still able to generate the specified voltage. While the system is far less complex than a brain, Dillavou says it is "more reminiscent of a biological system than, say, someone sawing an iPhone in half."

Future versions of this circuit could be useful for a remotely controlled planetary rover, Dillavou and Stern say. "You can just put it wherever it needs to go and then train it *in situ* to respond to the signals," said Stern. In addition, if part of the system gets smashed while deployed on another planet, it could still work.

At the meeting, Michelle Berry, a fourth-year PhD student at Syracuse University, presented theoretical research on a mechanical computer. Such a device would execute logic like a conventional computer but with physical forces instead of electrical signals. For example, the device could be designed to sense a force in its surroundings, which could initiate subsequent motion to allow the device to execute some task.

Berry studies networks of rigid rods connected by joints—similar to K'nex, the children's toy—and how forces travel through the network. In particular, she is developing a mechanical analog of a transistor. This is an area of the network that lets force propagate only under a specified condition, like a switch. In theory, you can connect these mechanical transistors to form mechanical logic gates, although Berry says these are still experimentally difficult to build.

A mechanical computer based on these jointed rods would also be far less complex than a regular computer, but it could offer advantages for specific applications. Berry names potential biomedical applications inside of a patient's body where "you don't want electronics, and you don't need crazy processing power," she says.

Nidhi Pashine designs and studies metamaterials that mimic a protein mechanism known as allosteric regulation. In allosteric regulation, a molecule binds to a site on a protein, often changing the protein's shape and allowing another site on the protein to become active. "This site [becomes] capable of undergoing a chemical reaction that it couldn't do before," says Pashine, who recently received her PhD from the University of Chicago.

Pashine's metamaterials, made of rubber, form a net composed of polygons resembling a spider web. This arrangement of polygons is random: its disorder is inspired by the arrangement of atoms in glass.

Pashine engineers each metamaterial to respond to force in a specific way. If you pull at one site on the metamaterial, the force propagates through the material to induce a desired motion on the other end. It's like if opening someone's front door caused a window to shut on the other side of the house, Pashine describes.

Typically, researchers use simulations to design their metamaterials, which fail to capture the complexity of real-world materials. Pashine came up with an experiment-based algorithm that avoids the limitations of simulations. In her method, she designs her network to respond correctly by removing links in the network based on measurements of the stresses in the metamaterial.

Pashine says that "pruning" a random network to create a metamaterial also offers design advantages compared to designing the network from the ground up. "It's much easier if you start with something random and then modify it," she says.

Video recordings of these and other programmable matter presentations will be available on the meeting website (march.aps.org) until June 19, 2021.

The author is a freelance science writer based in Columbus, Ohio.

ASHCROFT CONTINUED FROM PAGE 2

"What is the simplest model, the spherical cow model, that physicists could do? Have a solid state material with a sea of electrons that do not interact with each other," said José Menéndez a physicist at Arizona State University. "The approach is so logical and so physical … I really do think that it's one of the best physics books ever written."

Mermin attributes the success to repeated revisions and collaboration between himself and Ashcroft.

"I would write something that I could understand and send it back to Neil. Neil would then correct all the mistakes I had made and send it back to me. Every chapter went back and forth several times," he said. "Neil approached it more almost as a chemist than as a physicist, in the sense that he was deeply interested in materials he was talking about. I approached it more as a mathematician, in that I was interested in the structure of the theory. I think one of the reasons the book has been so successful is that we managed to combine those two very different perspectives."

Roald Hoffmann, a Nobel-winning chemist at Cornell whom Ashcroft collaborated with toward the end of his career also praised the book.

"*Ashcroft and Mermin* has a certain style and verve to it, aside from the pedagogically very clear orientation," he said. "It's very important to me, and I wish I had written something like that in chemistry."

Though Ashcroft was a "pen and paper" theorist, he was also instrumental to the development of density functional theory (DFT), according to his former graduate student, Jeff Neaton, a physicist at Lawrence Berkeley National Lab and the University of California, Berkeley.

"He viewed DFT as like a canvas of sorts," Neaton said. "I think he showed the community how to use DFT to explore specific realizations of physics he was interested in." In 1999, Neaton and Ashcroft used DFT to make the first prediction that lithium under high pressure would behave strangely, pairing up like diatomic hydrogen molecules.

"I feel like he was a role model who showcased what science should be and how it should operate," said Gaston. Ashcroft was especially attuned to making younger researchers feel comfortable and by all accounts, was extremely generous with his time.

As an undergraduate in Sri Lanka, Dias was stuck on a problem in *Ashcroft and Mermin*, so he decided to send an inquiry straight to the source. "I really did not expect to get a reply," he said. "Sure enough, he replied, and he walked me through the mistakes."

The author is a freelance writer based in Bellport, New York.

PHYSTEC CONTINUED FROM PAGE 3

May, PhysTEC program manager. "People really seemed to like the lightning sessions—one was on successful strategies from PhysTEC sites and the other on [Get the Facts Out] recruiting resources. Each talk was five to seven minutes to share ideas."

The most impactful session of the PhysTEC conference, which moved quite a few attendees to tears, was the presentation of the 2020 National Teacher of the Year award to Bouakham Sriri-Perez, from Duncan Polytechnical High School in Fresno, CA. In a brief, but emotion-filled talk, Sriri-Perez described her path, from spending her childhood in a refugee camp to becoming a decorated physics teacher. "What does this award mean [to me]? This is a win for teachers, for refugees and immigrants, and an opportunity to share my journey," she said.

To facilitate the kinds of interactive discussions that might usually take place at a PhysTEC conference, most of the non-plenary sessions were designed as interactive workshops, making use of Zoom breakout rooms for small group discussions. A discussion room was also available in Gather.town for "talk-outs," time set aside after sessions for attendees to gather and share their conference experiences. Table topic discussions, a new event from the 2020 PhysTEC conference that gave attendees a chance to sit down together and discuss specific topics from the conference, was also replicated in Gather.Town on the final day of the conference. "For table talks, we provide a set of topics with a topic at each table… essentially, you get people in the room, and give them the topics to discuss with their peers," said Roti Roti. "The goals are to provide a space for faculty to discuss the topic in their own context to get some really good ideas to take home. Goal number two is that, assuming folks take notes, we ask them to share those notes to improve the PhysTEC program."

Although networking and other aspects of in-person meetings are still difficult to replicate in an online space, post-conference surveys indicate that the online PhysTEC conference was a hit.

"This is the best online conference I have attended—well organized, clear communication, transparent navigation," said one attendee. "It's still not as much fun as an in-person conference, but it's the closest I've experienced. Very worthwhile, and I'm glad I came."

For more about the PhysTEC program visit physctec.org.

POLICY CONTINUED FROM PAGE 3

of New Mexico and the University of Texas at Austin. My research project focuses on advanced electrical conductors, and the overarching goal is to develop ultra-conductive materials to alleviate energy losses in electrical transmission and conversion. Further, my work involves understanding materials science. As I think about why most Americans should care about my research, I would tell them that it could lead to more efficient electrical devices and vehicles.

Speaking up about the importance of research is a key part of advocacy for me. I realize that not every person is an expert in science, and I do not take it lightly that taxpayer dollars are funding my research. Therefore, it is crucial that I not only advocate for research funding, but I must also be willing to tell members of Congress, my neighbor, and anybody else who is interested why science is important.

I can't underscore enough how helpful the APS GA staff have been in preparing me and so many other APS members to be successful in our advocacy efforts. For example, during Congressional Visits Day (CVD), the APS GA staff trained volunteers using video sessions; developed one-pager issue briefs to ensure members of Congress understood the policy issues we were advocating for; and provided opportunities for volunteers to share experiences during debriefing sessions that followed our meetings on Capitol Hill. Don't hesitate to let your voices be heard on the issues that matter most to our community. If you are unable to participate in CVD or similar APS activities, you can still make a difference by visiting APS GA's Action Center to start your advocacy journey.

Raju Ghimire, former Secretary (2019-2020) of the APS Forum on Graduate Student Affairs, is working on his PhD in nanoscience and microsystem engineering through a collaboration with the University of New Mexico and the University of Texas at Austin.

DATA SCIENCE CONTINUED FROM PAGE 1

I sharpened my skills on pharmaceutical product development and also gained insight into the entire drug development process. I then pivoted to digital health development, in which I now leverage data analytics skill sets that were gained in my physics education.

Dan: What is a typical day like for you as a data scientist?

Jie: My role is to lead testing of digital technologies, from experimentation to data analysis, in hope of generating new insights into patients' disease experience. To achieve this goal, I may take on various roles throughout the day as needed: as a program manager, a platform builder, an algorithm developer, or a scientific mentor. On a technical front, I help build data flow and employ various cloud-based tools to collect, transform, and analyze sensor-derived data. I spend my nerdy moments chewing on ML/DL algorithms and discussing them with the team. Most often, these are highly cross-functional and collaborative efforts and wouldn't succeed without good project management. I also spend a good part of my time serving as a program manager and coordinating efforts among various internal and external colleagues.

Dan: How did your background in physics prepare you for your career as a data scientist?

Jie: My physics background has set up a firm foundation for me with coding and data analytics skill sets; that makes it very easy for me to take on the role as data scientist. A physics education has also equipped me with quantitative thinking skills that are different from that of colleagues with a statistics or engineering background, which has added unique value to my work.

Dan: What advice would give someone who is interested in pursuing a career in data science?

Jie: Data science is an interdisciplinary field that combines programming, math, and statistics, with domain knowledge in various application fields. The domain knowledge (of your preferred industry sector) is an anchor for a successful data science career, and one would need to demonstrate a certain level of fluency and interest in such domains. Such knowledge could be new to physics students, though, as physics by itself is not an application-centric discipline. If you are interested in moving away from academia, I suggest exploring the various industry sectors as early as possible to find the one(s) that fits your interest and build up your knowledge accordingly.

Dan: What are some challenges you have encountered in your career and how did you overcome them?

Jie: In my personal experience, I have navigated a career that is very different from my physics background, and my daily tasks constantly call for learning new disciplines (e.g., fields such as chemical, engineering, statistics, clinical, medical, IT, regulatory, etc.). This is both fascinating and challenging at the same time. Justifying myself for a new task, or a new role, calls for not only an educational background (as my education background lends little insight to my skill sets), but also extra steps to generate evidence for my capability. I think passion is key in overcoming such challenges and staying on course in terms of career development. I have been incredibly fortunate to be able to work on problems that I am truly passionate about, which I believe is a great energy source for my career.

About Merck:

- Merck & Co. is a $48 billion global biopharmaceutical company that was founded 130 years ago.
- The company has focused on developing and bringing to market medicines and vaccines for many of the world's most devastating diseases.
- Merck employs cutting-edge data science to innovate new ways of communicating, measuring, and interacting in the development of new pharmaceuticals.

HISTORY CONTINUED FROM PAGE 2

as efficiently as it serves good. Upon you, therefore, rests the responsibility for moral and ethical use of technology."

He died on November 6, 1975, in Salt Lake City, just before aerogels experienced a resurgence of interest, thanks to the development of a safer, more efficient manufacturing method by French scientists in the 1980.

Aerogels continue to fascinate scientists as a material. For instance, in 2018, researchers at Newcastle University in the UK created a new type of aerogel inspired by dragonfly wings, which have the same porous, layered structure of an aerogel. When dragonflies emerge from the larval stage, their wings are wet and gel-like, but the insects produce bicarbonate molecules which release CO_2, blowing out all the moisture. The Newcastle team figured out how to mimic this process using bicarbonate of soda, instead of using high temperatures and pressures to dry the silica.

Further Reading:

Ayers, M. *The Pioneer: Samuel Kistler.* Berkeley: E.O. Lawrence Berkeley National Laboratory, May 2000.

Kistler, S. S. (1931) "Coherent Expanded Aerogels and Jellies," *Nature* 127: 741.

Han. X. *et al.* (2018) "Bioinspired synthesis of monolithic and layered aerogels," *Advanced Materials* 30: 23.

Correction

In the article "Effective Practices for Physics Programs Guide Makes its Debut," which appeared in the February 2021 issue of *APS News*, the Strategic Programs for Innovations in Undergraduate Physics (SPIN-UP) report was erroneously referred to as the "APS SPIN-UP Report." The report, which was not an APS project, was run by the National Task Force for Undergraduate Physics. SPIN-UP was published by the American Association of Physics Teachers, with support from the ExxonMobil Foundation, the American Institute of Physics, and APS.

FYI CONTINUED FROM PAGE 4

their spots atop the subcommittee responsible for NIH, though Blunt has announced he will not seek reelection in 2022.

On the House side, Rep. Rosa DeLauro (D-CT) is now chair of the Appropriations Committee following the retirement of Rep. Nita Lowey (D-NY) and is also continuing as chair of the subcommittee for NIH. Rep. Kay Granger (R-TX) remains the top Republican appropriator and all the Republican subcommittee leaders with science portfolios have kept their spots.

With the retirement of Rep. José Serrano (D-NY), Rep. Matt Cartwright (D-PA) is now chair of the Commerce-Justice-Science Subcommittee. Rep. Betty McCollum (D-MN) has switched to chairing the Defense Subcommittee from chairing the Interior-Environment Subcommittee, which is now led by Rep. Chellie Pingree (D-ME). Rep. Marcy Kaptur (D-OH) remains chair of the Energy-Water Subcommittee.

Notably, for the first time in a decade the Appropriations Committee leaders will be operating free of the constraints set by the Budget Control Act of 2011, which expired last year. However, they still must agree on an overall budget for the year, which is then divided up between the 12 subcommittees, and Republicans will retain influence over these figures unless Senate Democrats modify the filibuster. The topline budget level will bear significantly on the prospects for science agency budget increases, though separate infrastructure legislation could provide additional funding through the same process Democrats used in March to circumvent the filibuster and pass a $1.9 trillion pandemic recovery package.

The author is a Science Policy Analyst for FYI.

Published by the American Institute of Physics since 1989, FYI is a trusted source of science policy news that is read by congressional staff, federal agency heads, and leading figures in the scientific community. Sign up for free FYI emails at aip.org/fyi.

CORONAVIRUS CONTINUED FROM PAGE 1

could be useful in airports, schools, communities, and sports stadiums."

With funding from NSF's Rapid Response Research program, Yacamán's lab has been employing a technique called surface-enhanced Raman spectroscopy (SERS) to identify what are essentially viral fingerprints: Raman spectra unique to individual viruses, based on their molecular makeup. Using samples obtained from NAU's Pathogen and Microbiome Institute, Yacamán's team observed a signal completely unique to the SARs-CoV-2 virus. The presence of a COVID-19 infection could be established by matching a Raman spectrum from a sample against SARs-CoV-2's established fingerprint. "We are now totally convinced that we can identify the virus," said Yacamán.

In addition to the novel coronavirus, Yacamán's team has used the same technique to identify the fingerprints of other viruses, including other coronaviruses. The cov-NL63 virus, which causes a respiratory illness that shares some symptoms with COVID-19, produced a very different Raman spectrum. This ability to differentiate between diseases caused by different viruses, including between COVID-19 and the flu, has the potential to be an important diagnostic tool.

"It's frustrating when I go to the doctor and they say you have a virus...which virus?" said Yacamán "In the future [we could] have more of these tests to rapidly distinguish between viruses and get a good diagnosis."

Employing SERS as a method of testing for COVID-19 can help eliminate some of the balancing act between cost, speed, and accuracy that impacts traditional testing methods. The current gold-standard test for COVID-19 infection, the RT-PCR (reverse transcription polymerase chain reaction) test typically takes at least two days to produce results. Newer testing methods, like ELISAs (enzyme linked immunosorbent assays), can provide faster results, but sacrifice reliability, especially early in an infection. PT-PCR, ELISA, and other methods of testing for COVID-19 rely on expensive chemicals and non-portable lab equipment.

"[SERS] is a technique that only uses physics, no chemicals except nanoparticles, which are incredibly cheap to produce," said Yacamán.

Raman spectroscopy works in part by measuring the inelastic scattering of photons, known as the Raman effect—named for physicist C.V. Raman who observed the phenomenon in 1928 and won a Nobel prize for his discovery in 1930. The signal given off by the Raman effect can be very weak, but in SERS, substrates containing nanoparticles that interact with the surface proteins of a virus, such as SARs-CoV-2's spike proteins, act like antennas for a stronger signal.

While employment of SERS as a COVID-19 testing technique isn't yet possible due to the need for clinical studies, Yacamán expects such studies would yield promising results: similar studies to test the efficacy of SERS to detect breast cancer showed sensitivity of 92 percent and specificity of 96 percent, and he believes tests of SERS for COVID-19 would produce similar numbers. The next step, says Yacamán, is partnering with an institution like a university hospital, to start testing this technology.

In a panel following his scientific talk at the March Meeting, Yacamán discussed how, as a physicist, he became involved with trying to solve the practical, medical problem of COVID-19 testing.

"I learned [during my postdoc] that when you work on problems related to real problems people have, in industry or medicine, then your scientific impact is much bigger. At the same time, those problems are much more difficult because they're real problems—You can't make simple assumptions," Yacamán said. In a message to students, he adds "if you work in important, applied problems, the physics is more complex, but the results have more impact."

BACKPAGE CONTINUED FROM PAGE 8

brilliance among Black scientists can be interpreted as arrogance. Isabel Wilkerson describes these rules as "a subconscious code of instructions for maintaining a 400-year-old social order" [3].

Over the years, I've often been called upon to investigate specific issues of diversity at a variety of technology based or research-intensive corporations and institutions: hiring practices, performance evaluation fairness, promotion outcomes, incidences of overt discrimination, cultural biases, etc. One detailed longitudinal study of an annual review process uncovered particularly interesting insights. It's worth noting that the specific company's process was, on the surface, exceptionally rigorous, objective, and fair. The contributions of each member of the scientific staff was discussed in detail with input from a range of managers beyond the direct supervision. An immediate observation was that there was a marked difference in the first projects approved or assigned to the new Black scientist relative to peers with virtually identical academic backgrounds, reflecting a clear difference in expectations or level of confidence.

The conduct of science is inherently collaborative, but ignoring the possibility of overt racism, there is an enduring discomfort interacting across ethnic boundaries. Consequently, white managers, perhaps unconsciously, were often not forthcoming in communicating crucial information to Black scientists. Beyond inhibiting the work, this substantially impacted the extent to which those scientists acquired knowledge of the company's unwritten rules, strategic objectives, policies, and practices. Supervisors, too, were less candid in communicating performance rankings, whether positive or negative. Informal mentoring was less available to the Black scientist. While risk-taking and creativity are nurtured in a healthy scientific culture, risk aversion is almost necessary for Black scientists to survive. The evidence demonstrates that, for them, deviation from the norm is less acceptable by their managers, and a failed project is virtually impossible to overcome.

Later in the Black scientists' career, whatever exceptional performance and expertise they have achieved, when entering a new environment, a new organization, they must over and over again re-earn the reputation, the respect and acknowledgement even of competency that routinely accrues to high achieving scientists of other ethnicities. As a manager or leader, climbing the career ladder, Black scientists encounter the, often unconscious, psychological resistance to his or her leadership. This leads to behaviors that undermine or outright sabotage their decisions and their success. The Black scientist is subjected to the invisibility and ever present microaggressions that are well-documented throughout the literature on race relations. A quote from Toni Morrison captures one consequence of racism on the professional:

…the very serious function of racism is distraction. It keeps you from doing your work. It keeps you explaining, over and over again, your reason for being. [4]

The ultimate outcome I found in studying the annual review process was, for white scientists, the usual normal distribution. Black scientists, on the other hand, exhibited a distinctively bifurcated distribution, with one mean at the low end of the overall distribution and the other mean at the very high end. After much sifting of the data, enhanced by personal interviews with managers, it became clear that the Black scientist who did not quickly get anointed as a superstar entered a rapidly spiraling decline. The non-superstar Black scientist did not get well supported financially and otherwise, did not get opportunities to work on high profile, high visibility projects, did not get access to leadership in the company. Settling in the middle of the rankings was not a possibility.

Academia

Access to a physics career begins well before college with considerably greater preparation and prerequisite courses than for most other disciplines. For the typical Black precollege student in this country, this presents a considerable access barrier. It is well known that public schools in Black communities typically are woefully deficient in science and mathematics. In the small proportion of high schools in those communities that offer college preparatory mathematics and science courses, those who teach them frequently do not have even the minimum qualifications to carry out their assignments.

Looking at the pipeline from a broad perspective, we can incontrovertibly assume that among the approximately two million African Americans in underperforming high schools there are thousands of students who would have exceptional potential, if only given the necessary educational opportunity. NACME programs during the 1990s developed highly successful methods for identifying those high potential students, ignoring traditional measures. We know, for example, that measures, such as standardized tests, are artificial, largely reflective of family income and educational experience. The programs also demonstrated that intervention, exposing these students to exciting ideas in physics, providing intense accelerated college preparation in the mathematics and science "gatekeeper courses" can overcome the gaps in their earlier educational experience. Adequate financial support for college is also essential. The NACME program that took on students with triple digit combined SAT scores and marginal GPAs produced graduates from top ranked engineering colleges with 3.5 to 4.0 GPAs.

Throughout the academic pipeline, from precollege student through professional academic careers, Blacks have experiences similar to those discussed above in corporations. Assumptions about academic potential are made about students based on the color of their skin. At a prestigious private school, in eighth grade, my oldest son was placed in the lowest level mathematics course offered, despite having been selected through national competition for the prestigious Johns Hopkins Gifted Mathematics Program. Reviewing his homework assignments, I recognized immediately the misalignment and intervened to get him properly placed at his school. He wound up getting a degree in mathematics at Swarthmore College when he was 19 years old, solved a famous unsolved problem in number theory while a graduate student, and is now a professor of mathematics and Provost at a major university. This experience begs the question: how many exceptionally capable young Black boys who don't have a parent proficient in mathematics get inappropriately channeled out of the possibility of a scientific career very early because of race-based decisions?

As aspiring Black physicists progress through college and graduate school and into an academic career, they are typically immersed in a community that has no other Blacks. Their career paths are wholly reliant on those from other ethnic groups to judge their work equitably without prejudice. But faculty members, peers, university leaders are subject to the same conscious and unconscious biases found among corporate managers. They too are bereft of understanding of the history of the Black experience in America and of white privilege. They too could benefit from the kinds of educational experiences and training necessary to become "antiracist." Being an antiracist demands more than intellectual acceptance of abstract principles of social justice, equity, and equal opportunity. It demands proactive behaviors that expunge deeply ingrained racist behaviors and proactive refutation of white privilege.

…the very serious function of racism is distraction. It keeps you from doing your work. It keeps you explaining, over and over again, your reason for being. [4]

Conclusions

On a personal level, as a Black physicist who has had what might retrospectively look like an enviable career, I have been asked what I could possibly have to complain about. Life is difficult. Everyone has problems of one sort or another. The truth is that the opportunities that I've had—getting a great education in physics; then in the 1970s and 1980s, working at what was then one of the world's premiere research and development enterprises; in the 1990s, closely collaborating with the CEOs and other senior executives of the nation's most prominent technology-based corporations and research entities to formulate policies to advance the equity agenda; then ascending to the highest level in academia, as president for eleven years of The Cooper Union, then one of the nation's top three specialized colleges—have been all I could have dreamed of growing up as a Black male under segregated conditions in the 1950s and early 1960s. My career as a physicist and subsequently as a manager and leader in the scientific field has been enormously satisfying. I have personally been fortunate enough to have had a great many physicist friends and colleagues of all ethnic backgrounds—Black, white, Latinx, Asian, and others—faculty members, peers, leaders in the scientific community, university administrators, and board members to thank for their unbridled support and confidence as I traversed my career. But my personal history notwithstanding, systemic barriers remain, and those barriers intercept success from K-12 through college, graduate school and the workplace. Those barriers have prevented the physics community from making any meaningful progress in the fifty years since the end of legal segregation.

To be clear, the goal is equitable—not preferential—treatment. I've often heard the argument from white colleagues: "Why should my neighbor's family get any special acknowledgement for being Black? They live in a nice house, their earnings are equivalent to mine, they have all the same privileges that my family has." What this argument misses is that, in this country, skin color trumps socio-economic status. Even as a college president, I was never immune to the external racist forces that are deeply ingrained in our society. When driving with my three sons, we became four Black men in a car, automatically seen by police and, in certain neighborhoods, by residents, as suspicious, there for nefarious purposes. I will invariably be pulled over, and usually not politely. We are ordered to get out of the car and put our hands on the roof while they approach with weapons drawn. I venture a guess that not many of my fellow college presidents who are white have suffered such indignities or, indeed, as we all have come to realize now, serious risks of bodily harm, including death.

In the wake of the George Floyd murder, it has often been suggested that the mushrooming examples of police brutality and aggression are recent phenomena due to the increased militarization of urban police forces or the presence of a few "bad apples." The truth is that the only thing that is recent is the undeniable evidence resulting from the presence of cell phone cameras, CCTV, and other video sources. The inequities are deeply rooted in our culture; the violence against Blacks is systemic in police culture and always has been. Even Black police officers are indoctrinated into that culture.

However, as the unequivocal evidence of white privilege and systemic mistreatment of Black people have recently emerged, there appears to be a renewed vigor to right the wrongs in this country with respect to race. Many young whites are accepting the evidence and acknowledging the reality of white privilege. While some efforts that appear responsive to a moral imperative are merely commercial ventures to advance a profit agenda, there has been an unprecedented commitment of philanthropy and other capital investments to reduce the economic inequities in our systems. Various government entities, corporations and other pillars of our society are contemplating, if not enacting, sweeping policies to modify policing practices and to embrace diversity in all its dimensions.

I'm, of course, mindful of the exhilarating hopefulness we experienced in 1964 and 1965 following the passage of the Civil Rights Act and the Voting Rights Act, a hopefulness seen also following the Emancipation Proclamation (and, in Texas, Juneteenth), during Reconstruction, following the 13th, 14th, 15th, 19th, 24th, and 26th Amendments to the US Constitution, following Great Migration, following the Brown v. Board of Education Supreme Court decision, and following the election of Barack Obama. I'm mindful that each of the joyful moments was followed by a feverish backlash by "conservatives" to reclaim the prior conditions, severely moderating the anticipated progress. The relentless, persistent, cyclical history notwithstanding, I am going to allow myself to believe that the current generation is more enlightened and, through modern technology, more informed, than those of the past. I'm going to allow myself at this moment in the great American experiment, to exult in a hopeful optimism for the future of our nation. I'm going to allow myself to believe that we in the physics community will seize this moment of heightened consciousness to lower the barriers to access and reduce the impediments to career advancement for African Americans. With an honest commitment to change, I know that we can finally begin to make progress towards genuine equity in physics. We can recapture the 19th century promise we saw in Edward Bouchet's achievements.

The author is President Emeritus, The Cooper Union for the Advancement of Science and Art. This essay is adapted from the Fall 2020 Newsletter of the APS Forum on the History of Physics. The Introduction is adapted and updated from G. Campbell Jr., "United States Demographics" and "Critical Issues," essays in Access Denied: Race, Ethnicity and the Scientific Enterprise, eds. G. Campbell Jr., R. Denes and C. Morrison, Oxford University Press, 2000.

Notes and References

1. Ronald E. Mickens. "Bouchet and Imes: First Black Physicists," in A. M. Johnson, ed., *Proceedings of the 12th Annual Meeting and 16th Day of Scientific Lectures of the National Society of Black Physicists*, pp. 1-14, National Society of Black Physicists, 1989.

2. See, for example, Vivian Hunt, Dennis Layton, and Sara Prince. "Why diversity matters," McKinsey & Co., January 2015; or J.J. DiStefano and M.L. Maznevski, Effective management of diversity: A theoretical model with empirical evidence. Presented at the American Association for the Advancement of Science Annual Meeting, 1994.

3. Isabel Wilkerson. "America's Enduring Racial Caste System," *The New York Times Magazine*, July 5, 2020

4. Toni Morrison, "A Humanistic View." Speech delivered at Portland State University, May 30, 1975.

THE BACK PAGE

A Black Life in Physics

BY GEORGE CAMPBELL JR.

In 1876, Edward Bouchet received a PhD in physics from Yale University. Just two years earlier, he had graduated *Summa Cum Laude* and Phi Beta Kappa, also from Yale, with a bachelor's degree in physics. His remarkable academic success and substantial early contributions to research as a graduate student suggested a promising future in physics. Except for one thing. Edward Bouchet was Black. Bouchet's doctorate was, in fact, the first-ever PhD awarded to an African American by an American university in any field. Initially intent on a research career after graduation, Bouchet could find a job only at the Institute for Colored Youth in Philadelphia. At the pinnacle of his career, his last job, he served as principal of a high school in Ohio [1].

The tragic story of Edward Bouchet's life is not a surprise to anyone familiar with American history. It is, nevertheless, noteworthy that physics was the first profession to allow penetration of the previously impervious barrier to education for Black people. This was just before the dawn of the twentieth century when the development of relativity and quantum mechanics, fundamental breakthroughs in physics, created an authentic Kuhnian paradigm shift. Physicists in this emerging era of enlightenment were steeped in the pursuit of objective truth. It might, therefore, have been natural at that time to anticipate a leadership role for physics in breaking down the irrational, obsessive American practice of racial exclusion.

It was not to be. In fact, a half century later, the decidedly unscientific voice of William Shockley, a Bell Labs physicist who had shared the Nobel Prize for the invention of the transistor, used his prestigious, highly visible platform to promote a thinly veiled hypothesis of white supremacy. From the day that Bouchet received his PhD almost a full century would go by—coincidentally, until the time I was in graduate school—before the doors to an advanced physics degree and to a career in physics would slowly begin to creak open. While I was a graduate student, the average annual number of physics doctorates received by African Americans in the United States was seven out of a total of about 1,000 awarded. During the more than 40 years since, considerable resources spent by private philanthropy, the National Science Foundation, the National Academies, Congress and others have been devoted to improving access to education and careers in science for minorities. Most of the resources were distributed to a multitude of colleges, universities, and a cottage industry of minority programs. The undertakings have been piecemeal, uncoordinated, incoherent; and no one entity has ever had enough resources to move the needle alone.

A substantial fraction of the finances was dedicated to conducting studies aimed at determining the best strategies and corrective measures, deciphering what the data tells us, uncovering what works and what doesn't. There now have been enough studies to populate a moderately sized library. I have frequently suggested to funding sources that current resources would better serve the goal of equity if they were devoted to taking action based on knowledge we have already accumulated. In the annals of education research we have copious examples of successful practices and strategies to overcome the gaps in educational opportunities and professional development of minorities. NACME, Inc., the National Action Council for Minorities in Engineering, which I had the honor of leading during the 1990s, is a nonprofit organization that began at the National Academy of Engineering in 1971 to address the underrepresentation of minorities in engineering. It was funded by a coalition of private philanthropy, led by the Sloan Foundation and the nation's largest technology-intensive corporations. Its board was comprised of Chief Executive Officers of those corporations, several university presidents and president of the National Academy of Engineering. Over the years, NACME conducted several financial studies, yielding compelling recommendations and outlining the amount of financial *programmatic* resources required to achieve equity. Collective funding from all sources to all relevant programs has never reached more than 20 percent of what was recommended. Of course, with a serious commitment to the mission, the founding organizations could easily have fully supported the effort.

While in some disciplines, there has been measurable, though marginal progress, the bottom line in physics is that

George Campbell Jr.
CREDIT: COOPER UNION

in 2017, the number of PhDs awarded to African Americans in the US was 14 out of 2,000, the identical proportion as in the 1970s. We have made virtually no progress toward racial inclusiveness over the last half century. We have not embraced the considerable talents, creative energy, and abilities underrepresented and underdeveloped in the field. Rectifying this historical pattern would substantially enhance and enrich scientific advancement in this country. Resounding studies have shown that diverse groups of professionals devoid of racial hang-ups working in collaboration have considerably higher performance potential than heterogeneous groups [2].

Over the course of my career at one time or another, I have been intensely engaged with the entire educational pipeline. I have worked both in academia and industry, and in what follows, I will share some of the insights I have gained into what strategies are effective in eliminating impediments to education and career advancement in the sciences for African Americans.

The Corporate Sector

During my early physics career at Bell Laboratories, I suggested to a colleague, another distinguished Nobel Laureate—not of the Shockley disposition, but a very thoughtful physicist who cared about issues of equity—that the company should be putting a greater effort into identifying, recruiting, and hiring Black physicists. His very sincere response was, "Anybody in the country who is capable of doing what we do here at Bell Labs is bound to eventually come to our attention, so we don't have to go out beating the bushes." What he was missing was that the opportunities for young Black scientists to demonstrate their capabilities both as students and as professionals were extremely limited as a consequence of the still-prevalent social structures encumbered by racial bias. To be fair, Bell Laboratories did have among the nation's most successful scholarship and fellowship programs in the sciences—essentially growing our own—and at one time employed almost one half of all Black PhD physicists in the United States. Equally important, Bell Labs was a pioneer in developing and delivering innovative, hard-hitting programs to educate managers about cultural and structural biases inherited from centuries of ill treatment of Black people.

One such program that began in the 1970s was called the Urban Minorities Workshop. After going through a developmental phase, the top executives at Bell Labs went through the Workshop and decided to make it a requirement for all new managers. The one-week Workshop thoroughly immersed participants in the Black experience. There were tours of depressed Black neighborhoods in Newark, NJ and visits with civil rights and other community organizations. More importantly, the Workshop confronted participants with their conscious and unconscious biases, latent and overt racial attitudes and learned instinctive assumptions and behaviors toward Black people.

Most white managers came into the program with little or no experience interacting with African Americans either socially or professionally, without having ever given much thought to racial issues and largely ignorant of America's history of oppressive treatment of African Americans. This was not surprising. Very few Americans then and now were well educated with respect to the history of the African American experience in the United States. It remains virtually impossible to this day to find a public or private school K-12 curriculum that includes more than a perfunctory mention of slavery or any mention whatsoever of its successor policies and outcomes—Jim Crow laws legalizing segregation, *de facto* legalized lynching, voter suppression, mass incarceration, economic inequities, wealth disparities and daily mistreatment, racial discrimination and systemic police brutality against African Americans. Few, if any, had any inkling of how different the Black experience is from other ethnic groups in the United States.

I'm reminded of a conversation I had with a senior executive of AT&T in the 1970s, during my time at Bell Laboratories. I recounted a then-recent experience with the police, when two officers accosted me on my front lawn, with guns in my face. I was apparently "suspicious" to them while immersed in and tending to my shrubs. The executive's honest and understandably incredulous reply was, "Surely you weren't concerned for your safety in the moment. After all, they were *police officers* holding the guns!" For him, it was unfathomable that a police officer might have posed a danger to an innocent person. This had to be an example of a simple mistake that had nothing to do with race, a "single isolated incidence."

Beyond the anecdotal, it would have been rare for any of the Bell Labs managers to encounter any rigorous historical academic treatment of these matters. In any case, the managers universally rejected responsibility for America's history of oppressive policies. After all, they had taken no part in slavery, in lynching or other such practices. Up to that point, they had undergone no conscious intellectual engagement with the benefits of what we now call white privilege, which the Urban Minorities Workshop brought to the fore. Led by three young Black urban professionals, the program was raw, hard-hitting, contentious, dissonant. Black managers, too, were not spared confrontation in the Workshop. They, too, were prodded over lifestyles that afforded them, at least in part, those privileges conferred by economic class not available to the majority of African Americans.

After several years, there had developed a critical mass of white managers who had been outraged by the Urban Minorities Workshop experience, and who petitioned the company to eliminate it. They felt ambushed, coerced, abused, and belittled in the program. To some extent that was part of the design—to expose them briefly to the ignominies that are all too common for Black people. Admittedly, a less caustic, more amiable approach may have found greater acceptance. However, the managers' rebellion was also consistent with a long-standing American pattern of resistance to the nation's history with respect to race, a resistance to change. Ultimately, under threat of legal action, the company capitulated and abandoned the Workshop. Nevertheless, throughout the corporate sector, the need remained for a rigorous program to educate the workforce about the history of racism and their own, perhaps passive, role in its perpetuation.

In a broader context, for scientists—or indeed any professional—to flourish, whether in corporate America or in academia, it's important to know the unwritten, often socially constructed, rules and processes that underpin success. And for Black scientists, it's important to understand that the rules are different for them relative to their white peers, in much the same way that the criminal justice system works differently for Blacks relative to white citizens. The presumption of innocence does not work the same way. Mistakes are weighed more heavily. Forgiveness is nonexistent. Just as decisiveness among women can be regarded as vitriolic,

BACKPAGE CONTINUED ON PAGE 7