October 2019 • Vol. 28, No. 9
aps.org/apsnews

APS NEWS

A PUBLICATION OF THE AMERICAN PHYSICAL SOCIETY

CAREERS

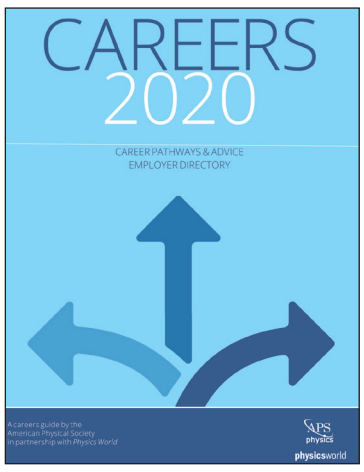
A New Guide for Job Seekers

BY LEAH POFFENBERGER

For some early career physicists, the way forward after receiving a degree is clear—heading towards academia or a field that grabbed their interest in school. But others may find themselves wondering what to do with a physics degree or where to go next in their careers.

APS and the Institute of Physisc Publishing (IOPP) in the UK have teamed up to alert early-career physicists to the many possibilities in the field with a new publication: the *APS Careers 2020*. Modeled after *Physics World Careers* published by the IOPP, which focused on career information for UK and EU physicists, the APS guide provides invaluable information for job seekers in the United States. The guide will be available to all APS members by the end of October.

Crystal Bailey, Head of Career Programs at APS, has been working closely with Tushna Commissariat and Edward Jost, both of IOPP, to launch the new publication and provide a valuable



resource to APS members.

"*APS Careers 2020* is targeted to all members, with a special focus on early career physicists," says Bailey, who managed the project from the APS side. "We made an effort to make sure this guide has something beneficial to members at all levels of their careers."

And serving members, espe-

CAREER GUIDE CONTINUED ON PAGE 4

INTERNATIONAL AFFAIRS

Highlights from the 2019 Canadian-American-Mexican Physics Conference

BY PALOMA VILCHIS

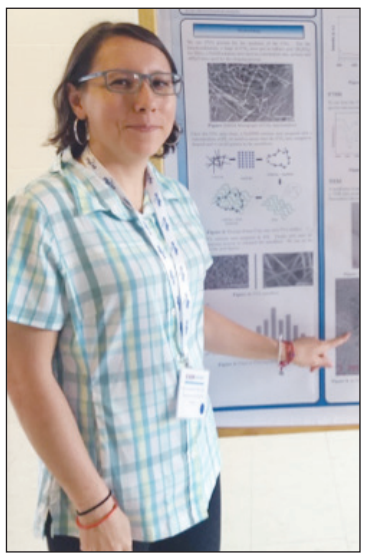
The Canadian-American-Mexican (CAM) Graduate Student Physics Conference is a gathering of physics students from Canada, Cuba, Mexico, and the United States, and has been organized every two years since 1994. This year, the CAM conference took place from July 24 to 27 in Sudbury, a small town in Ontario, known for the world-class science facilities of SNOLAB—the Sudbury Neutrino Observatory—located in a nickel mine two kilometers underground.

The CAM Conference was hosted jointly by SNOLAB and Laurentian University. Laurentian opened its doors to around a hundred graduate students for the conference, which featured plenary talks and parallel sessions on a variety of topics, tours of SNOLAB, and various networking and career growth opportunities.

The conference kicked off before registration with a tour of SNOLAB and SNOLAB+, the 6300 m^2 addition to the original facility. We dressed in mining gear, took the mine elevator, walked two kilometers, and finally, at the entry of the lab, we left our mining gear behind. The group was divided to shower and get dressed in clean room gear—a process the scientists and employees at the lab do every day. We saw PICO 40 and PICO 60, which are both dark matter detectors, and the beginning of the construction of the Helium and Lead Observatory (HALO), which will be used to detect supernovas.

After the tour, we returned to Laurentian for a special function in the planetarium: Paul-Émile Legault, the director of the facility, gave a talk about how to find constellations with the identification of a specific star at any time of the year. We then split into groups for an evening of networking at different locations around Sudbury.

On Thursday morning, students gathered in the main conference



Paloma Vilchis

room for the first plenary of the day, given by Adrien Liu (McGill University), a cosmologist, who spoke about his research on the beginning of our universe's history,

CAM CONTINUED ON PAGE 6

EDUCATION AND DIVERSITY

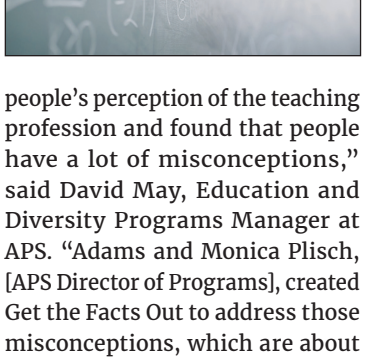
New APS Program Promotes Positive Perceptions of STEM Teaching

BY LEAH POFFENBERGER

Twenty years ago, APS launched the PhysTEC program to help address a shortage of physics teachers in the United States through teacher training programs. But some students may still shy away from pursuing STEM education as a career, due to misconceptions about teaching as a profession.

To address the myths about teaching and improve the perceptions of high-school teaching as a career, APS has launched the Get the Facts Out program in partnership with the American Association of Physics Teachers, the American Chemical Society, the Mathematical Society of America, and the Colorado School of Mines. Funded by a National Science Foundation grant, the project will provide resources for reaching STEM majors interested in teaching.

"Our PhysTEC partner, Wendy Adams [at the Colorado School of Mines] had done a lot of research on



people's perception of the teaching profession and found that people have a lot of misconceptions," said David May, Education and Diversity Programs Manager at APS. "Adams and Monica Plisch, [APS Director of Programs], created Get the Facts Out to address those misconceptions, which are about teacher compensation, benefits, and job satisfaction."

Many prospective physics educators are choosing other careers

PROGRAM CONTINUED ON PAGE 7

UNITS

The APS Forum on Outreach and Engaging the Public

BY ABIGAIL DOVE

Over two thousand members strong, the Forum on Outreach and Engaging the Public (FOEP) is a home for people who believe that telling the world about physics is just as important as the research itself. The forum provides a platform for physicists interested in public outreach—science writing, press relations, policy, public lectures—to connect and share ideas and best practices. Many members are well-known authors and physics communicators.

FOEP's mission of communicating physics to the general public is especially crucial in today's political climate, where attacks on science—from climate change to vaccine safety—have become commonplace. To this end, APS has recognized the importance of "expand[ing] public appreciation of physics" in its most recent Strategic Plan (see *APS News* March 2019), and with good reason: The best defense against assaults on science is a scientifically literate populace.

FOEP started in 2007 as an ad hoc committee within the APS Committee on Informing the Public (CIP), gaining the charter to become an official standalone forum in 2011. Although they do related work, FOEP and CIP are now separate entities: CIP's charge is to provide guidance to the APS organization for how to reach the public, whereas FOEP's charge is to provide the tools to APS members

Don Lincoln

Jim Kakalios

to be able to learn how to engage the public and become effective communicators of science.

At the institutional level, FOEP's main platforms include educational workshops to train people with an interest in outreach. Beyond practical advice for more effective science communication, some training sessions also provide specific insight into how to enter the world of science blogging, podcasting, and social media, or tips for writing op-eds for larger platforms like *The New York Times* and *The Washington Post*.

"By and large we're not born with communication skills," noted FOEP secretary/treasurer Dan Dahlberg (University of Minnesota), "You have to practice and learn the most effective way to do it and that's not an easy thing to do."

At March and April Meetings, FOEP is known for its highly-attended sessions where APS members can hear from inspiring figures in the science communication world. Past speakers have included Chad Orzel (author of the popular "How to Teach Physics to Your Dog" books), Sean Carroll (book author and host of the Mindscape podcast), Henry Reich (host of the YouTube channel One Minute Physics), Clifford Johnson (graphic novelist and a consultant for the physics aspects of several recent Marvel movies), and Kenneth Chang (longtime *New York Times* science reporter). APS members may also remember FOEP's extremely popular physics-themed Escape Room from the most recent March Meeting (see *APS News* April 2019).

While FOEP members are involved in a wide variety of outreach activities, the common thread is convincing the public that science—and particularly physics—is important. According

FOEP CONTINUED ON PAGE 7

Revised 10/16/2019

DEVELOPMENT

Industrial Physicist Selects APS as Sole Beneficiary of Generous Estate Gift

BY MARIAM MEHTER

After obtaining his degree and carrying out postdoctoral research on amorphous semiconductors, Suha Oguz worked as a scientist at the corporate research lab of a defense contractor. His career followed a path into technical management, and he eventually retired after 11 years as Vice President of Research and Development for a $7 billion business. He credits his success to being able to bridge the gap between the engineers and scientists working on technical research, on the one hand, and the business development staff and lawyers on the other.

Oguz remembers numerous occasions when the business staff did not like conclusions reached through rigorous experiments and instead pushed for interpretations not supported by those experiments and advocated "alternate" facts.

"Science, basically, is not a matter of opinion. It's a matter of objective observations, theories, and hypotheses. These are the kinds of things you can appreciate about science without being a scientist," says Oguz. He feels that a basic level of science literacy can enable those outside the sciences to understand and appreciate the rigor, objectivity, and utility of science and its pivotal role in their lives.

As an industrial physicist, Oguz recalled a conversation with a plumber at his laboratory who remembered a nitrogen balloon science demonstration from grade school years ago. Oguz was shocked and surprised by how much of an

Suha Oguz and Leslie Lord

impact that one moment had made and was impressed that the plumber had a warm feeling towards and an understanding of physics.

"Instead of viewing himself completely outside science, he felt very comfortable that he could contribute something," recalls Oguz.

Oguz and his wife, Leslie Lord, had been considering ways to combat science illiteracy and promote the appreciation of science. They have discussed their legacy and their wish to make a lasting impression by supporting science. Lord spent many years in the nonprofit world, most recently serving on boards of organizations that provide students with resources such as broadband internet. After some research and thought, they found their answer in the APS education, diversity, and public engagement programs and identified a way to make an impact.

GIFT CONTINUED ON PAGE 7

THIS MONTH IN

Physics History

October 1842: William Grove's Letter to Faraday Describing a Fuel Cell

Coal and oil were the fuels for industrial and technological development in the 19th and 20th centuries, but the world might have looked very different if "gas voltaic batteries" had dominated instead. It was a Welsh judge and scientist named Sir William Robert Grove who invented a battery that turned hydrogen and oxygen into electricity and water. Science historians generally deem his invention to be the first bona fide fuel cell.

Grove was born in Swansea, Wales, to a local magistrate. He was privately educated before attending Brasenose College at Oxford University, where he studied the classics, graduating in 1832. He became a lawyer in 1835, but his scientific interests led him to join the Royal Institution that same year. He wrote his first scientific paper on his honeymoon in 1837, proposing a new voltaic design for electric cells. It was published in October in the *Philosophical Magazine and Journal of Science*.

William Grove

In his paper, Grove noted presciently, "it seems probable that at no very distant period voltaic electricity may become a useful means of locomotion, the arrangement of batteries so as to produce the greatest power in the smallest space becomes important." Indeed, the German engineer Moritz Hermann von Jacobi used an array of Grove cells to power a boat on a river in St. Petersburg shortly thereafter.

The Grove cell used zinc and platinum in dilute and concentrated sulfuric acid, respectively, to generate a strong current, which made it a favorite for powering the fledgling telegraph industry. But as the technology became more widespread, Grove cells turned out to also emit a poisonous gas—an occupational hazard for operators working in offices filled with rows of Grove cells. The telegraph industry also needed constant voltage, and Grove cells depleted quickly, so his invention was eventually displaced by better alternatives.

At the dawn of the 19th century, two British scientists—William Nicholson and Anthony Carlisle—had written about how to use electricity to turn water into hydrogen and oxygen. Grove's insight was to run the process in reverse with platinum electrodes, a material that catalyzes the recombination of oxygen and hydrogen. He put the platinum electrodes in containers of oxygen and hydrogen each immersed in a bath of sulfuric acid to form a single cell, then wired several cells in series to make what he called a "gas voltaic battery.".

In October 1842, Grove wrote a letter to Michael Faraday at the Royal Institution about his invention. "I have just completed a curious voltaic pile which I think you would like to see," he wrote, and went on to describe an instrument that was "composed of alternate tubs of oxygen and hydrogen through each of which passes platina foil so as to dip into separate vessels of water acidulated with [sulfuric] acid. With 60 of these alternations I get an unpleasant shock…" He subsequently published an 1843 paper in the *Philosophical Magazine and Journal of Science*, offering details of the thirty experiments he conducted with the cells, "all with the same general result."

Grove must have been especially pleased, since the gas battery provided evidence for his fledgling theory of the correlation of physical forces—a precursor to our modern concept of conservation of energy. He published an essay describing his theory in 1846, arguing that "heat, light, electricity, magnetism, chemical affinity, and motion, are all correlative, or have a reciprocal dependence," and therefore, "either may, as a force, produce or be convertible into the other, this heat may mediately or immediately produce electricity, electricity may produce heat; and so of the rest." But Grove never fully developed his theory qualitatively. That achievement fell to Hermann von Helmholtz in 1847, building on earlier work by James Prescott Joule and William Thomson, among others.

Grove also invented one of the first incandescent light bulbs and collaborated with John Peter Gassiot on photography, notably daguerrotypes and calotypes. "It would be vain to attempt specifically to predict what may be the effect of photography on future generations," he wrote for the London Institution in 1842. "A process by which the most transient actions are rendered permanent, by which facts write their own annals in a language that can never be obsolete, forming documents which prove themselves—must interweave itself not only with science but with history and legislature."

LETTER CONTINUED ON PAGE 6

APS NEWS

Series II, Vol. 28, No. 9
October 2019

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APS News (ISSN: 1058-8132) is published monthly, except for a combined August-September 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.

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UNITS

APS Forum on Physics and Society Video Presentations Now Available

The APS Forum on Physics and Society sponsored several sessions at both the March Meeting in Boston and the April Meeting in Denver this year. These talks were recorded and are available online. **YouTube links to all of the video recordings of these sessions are available on the online version of *APS News* at aps.org/apsnews**:

APS March Meeting in Boston

The Future of U.S. Nuclear Forces: What Do We Need?

Steve Fetter (University of Maryland): Nuclear Modernization, ICBMs, and Launch On Warning

Lisbeth Gronlund (Union of Concerned Scientists): US Plans for New Nuclear Warheads

Richard Garwin (IBM): Current Nuclear Weapons Issues, and Sid Drell's Contributions to Arms Control and Strategic Stability

Stewart Prager (Princeton University): Engaging the Physics Community in Nuclear Threat Reduction

The Politics of Science Advising

John Holdren (Kennedy School at Harvard University; President Obama's Science Advisor): Speaking Science to Power: Providing S&T Advice to Governments

Celia Merzbacher (Oak Ridge National Laboratory; former Executive Director, President's Council on Science and Technology): Federal Policy Making: Perspectives from Inside and Outside Government

Andrew Zwicker (Princeton University; New Jersey Assembly): Advice from a Scientist-Policy Maker on Giving Advice to a Policy Maker

Nathan Phillips (Boston University): Science Legislative Fellow Advisors for State Legislatures

Iran, North Korea, and Nuclear Proliferation

Zia Mian (Princeton University, 2019 Szilard Lectureship Award recipient): Scientists and Today's Struggles Against Nuclear Weapons: What Would Szilard Do?

R. Scott Kemp (MIT): Iran, North Korea, and the Renewed Challenge of Proliferation

Alex Glaser (Princeton University): Verification of Denuclearization

Rachel Carr (MIT): Can Neutrino Detectors Strengthen the Nonproliferation Regime?

FPS VIDEOS CONTINUED ON PAGE 6

RESEARCH UPDATE

Sensing Seizures with Machine Learning

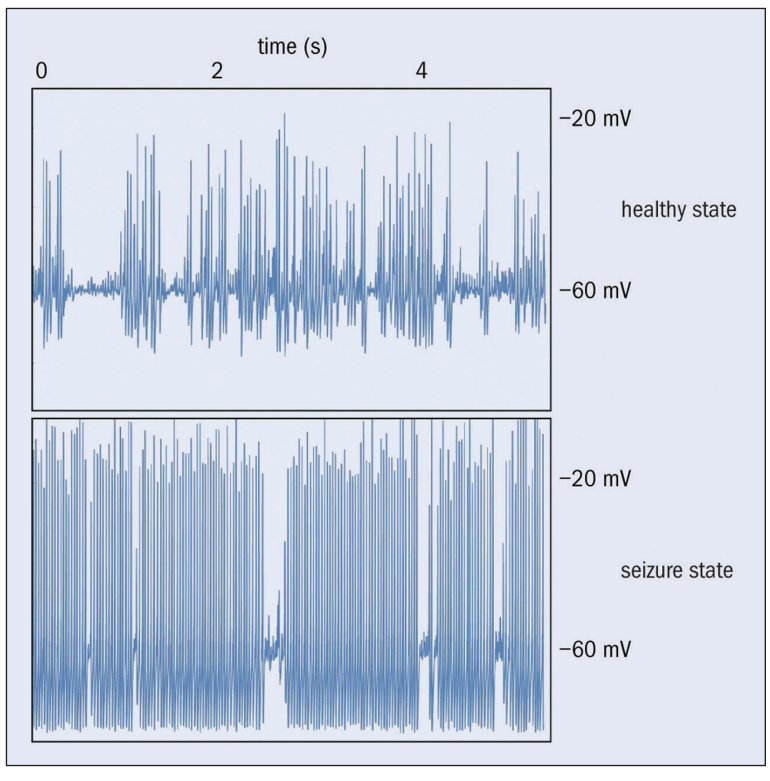
BY LEAH POFFENBERGER

In the United States alone, roughly three million people live with epilepsy, a disorder resulting in chronic seizures. Many of these people are able to control the disorder with treatment, such as medication or surgery, but others with uncontrolled epilepsy face a number of limitations, such as not being allowed to drive a car.

Louis Nemzer, a biophysicist, and a group of collaborators at Nova Southeastern University are taking an interdisciplinary approach to improving quality of life for people with uncontrolled epilepsy: The group is developing a device that would use machine learning to alert wearers to an oncoming seizure, acting as an early warning system, and they presented their latest results at this year's APS March Meeting in Boston.

"Patients with diabetes have real-time continuous glucose monitors that can give alerts when their blood sugar is too high or too low—we'd like to have something similar for people with epilepsy," says Nemzer. "You'd have some kind of wearable device, small and lightweight, to alert a patient to take action and get to a safe space when a seizure is likely to occur."

AI CONTINUED ON PAGE 6



Simulated healthy (top) and seizure (bottom) brain electrical patterns as generated by computer model of a neural network. IMAGE LOUIS NEMZER/PHYSICS-WORLD.COM

MEETINGS

The 40th International School for Young Astronomers in Egypt

BY SULTANA N. NAHAR

During the spring of 2018, Egypt hosted the 40th International School for Young Astronomers (ISYA) under the auspices of the International Astronomical Union (IAU) in Africa. It featured an impressive breadth of lecture topics, with hands-on experiences provided by an international team of lecturers in an accessible style, and group homework projects and group presentations by the very enthusiastic and dedicated participants.

ISYA has been organized by IAU since 1967 with the objective of broadening the perspective, knowledge, and awareness of astronomy through lectures from a team of international faculty on selected topics, in addition to seminars, practical exercises and observations, and opportunities to exchange experiences. ISYA is held mainly in developing countries, and attracts top postgraduate students pursuing a Master's Degree or PhD and young faculty members from the host country and neighboring countries in the region.

The effective structure of ISYA and its long-lasting impact on the participants suggest the possibility of creating a similar school for young physicists. APS, with its fast-growing international membership, could play a very important role in the enrichment and popularity of physics.

The 40th ISYA had 30 participants from eight countries: Egypt, Ethiopia, Ghana, Madagascar, Nigeria, Rwanda, Sudan, and Tanzania. Lecturers came from eight countries: Algeria, China, Egypt, Mexico, Norway, Russia, Spain, and the United States. The local organizer, the National Research Institute of Astronomy and Geophysics (NRIAG) at Helwan, arranged one week of the school at the Kottamia Observatory, which provided the opportunity for night observations, and two weeks at the Cataract Pyramids Resort near Cairo. Support came from Egyptian Academy of Scientific Research and Technology, NRIAG, and other educational institutions.

To make ISYA as accessible as possible for students and lecturers, IAU bears all costs related to the travel for international participants. The host country covers food, internal transportation, and lodging, typically through support from the Ministry of Higher Education and Research and donations from various organizations in the country.

I was an international lecturer for ISYA, and I gave talks on atomic processes in astrophysical plasmas, x-ray spectroscopy and plasma opacity of the sun. Other lecturers covered a variety of astronomy topics: general behavior of variable stars, interstellar matter, star formation, observational astronomy, optical photometry and spectroscopy, radio astronomy, solar system and solar physics, stellar astronomy, and stellar structure and evolution. Attendees also participated in hands-on sessions on data reduction and analysis.

The lecturers were passionate about both astronomy and helping ISYA students. During his lectures, Oleg Malkov, Department Head of Astronomy of Moscow State University, would run up the steps of the large auditorium to check whether the students were able to produce Hertzsprung-Russell diagrams of luminosity and temperature to classify a sample of stars from the GAIA databank.

In the evening all participants would go back to the large lecture room to work enthusiastically on the group projects until midnight. Often the lecturers would join them for encouragement but would do their own work. Past participants are often eager to sign up as lecturers to give something back to the program. The ISYA experience continues to inspire Somaya Saad who is the Head of the Center of Scientific Excellence in Astronomy and Space Science for NRIAG and local organizer of ISYA, and Nassim Seghouani who is the Director of Research at the Center of Research for Astronomy, Astrophysics, and Geophysics in Algeria.

During the weekends, students and lecturers took breaks from astronomy to see the sights of the host country. They visited the pyramids at Giza, rode a boat on the Nile, ate traditional Egyptian meals, and visited historical sites in Alexandria. Everyone gained knowledge of astronomy and memories of Egypt that will have a long-lasting impact.

Sultana Nahar is a professor of astronomy at the Ohio State University, co-director of the STEM ER Center, and adjunct professor of physics at Aligarh Muslim University and Cairo University.

ISYA group holds banner in front of a pyramid in Giza, Egypt.

CAREER GUIDE CONTINUED FROM PAGE 1

cially those just starting out, is a key component of the recently implemented APS Strategic Plan, which states that "... to attract and retain members and to fully serve the current and next generation of physicists, we will grow and broaden the APS membership to include more physicists in industry and the private sector, and provide additional tangible member benefits."

The guidebook contains a wealth of information focused on how someone with a physics degree can get a job outside of academia—and what some of those jobs are. More standard career-hunting advice, such as how to tailor a résumé for industrial job applications, is coupled with profiles of physicists with unconventional jobs. The guide also features a directory of companies, both industry and national labs, that are looking to hire people with physics degrees.

"Even though most physics graduates will pursue career paths outside of academia, many physics students will have only been exposed to academic research careers by the time they graduate," Bailey noted.

"A physics degree is really a platform to take on genuinely almost any job anywhere in the world, and we want to make sure they know that so they don't ever feel limited," said Commissariat, reviews and careers editor for *Physics World*, IOPP's membership magazine.

For the past three years, IOPP has been producing their own guide as an expansion of the careers information that was originally published in the member magazine.

"It was a lot of timeless stuff that we wanted people to see more regularly, so we put together the *Physics World Careers* guide with some of our best content coupled up with some profiles," says Jost, Head of Media Business Development at IOPP. "It's gone down really well with our membership here at the Institute—one member claimed it was one of the best things he'd had as a member benefit in years of being a member at the institute."

In October 2018, APS was approached by IOPP with a proposal to partner in creating a version of the *Physics World Careers* guide that was appropriate for US audiences. Together, APS and IOPP produced a collection of over 20 pieces of content for the *APS Careers 2020*, with the needs of APS members in mind.

Bailey worked closely with the IOP team to ensure that all parts of the guide came together in time for launch in October 2019. The APS communications group ensured that the publication is consistent with the APS brand and have created several promotional ads for APS programs to be included. Bailey also curated a number of professional development articles and profiles from a library of existing content to be included in the guide, as well as provided information to create new articles focusing on APS programs (such as the PIPELINE program, the IMPact program, and others).

As part of these contributions, APS has also helped connect the IOPP sales team with US companies and national labs that could be featured in the employer directory, which was the most difficult aspect they encountered in expanding into US markets.

The directory, for example, includes the same type of information from each company that participated to ensure an easy comparison for job seekers. An important addition to this section, which keeps the international membership of APS in mind, is a question on whether companies require their employees to have a US visa. Articles are also included in the guide profiling some of the careers programs offered through APS that provide additional support for early-career physicists.

In addition, a popular section from the *Physics World* guide called "Once a Physicist" will be reprised in the APS guide, profiling people who have physics degrees who have used them to do something completely different.

"We've selected articles that feature careers in industry, high school physics teaching, and entrepreneurship; there is also a multi-page feature on careers in the field of medical physics," Bailey said. "APS Careers 2020 is a tangible benefit that we are glad to be making available to our members and the broader physics community."

For more on career resources at APS, visit aps.org/careers.

GOVERNMENT AFFAIRS

APS Members Make the Case for 'Keep STEM Talent Act of 2019'

BY TAWANDA W. JOHNSON

APS members are tenaciously doing their part to highlight the importance of the Keep STEM Talent Act of 2019, which would allow students to proclaim "dual intent," provide green cards to international students who earn advanced STEM degrees at US institutions, and secure job offers from US employers in fields related to their degrees.

"International students and visiting scholars play a critical role in our theoretical physics research group's efforts. We need to continue the flow of top talent into STEM fields, which benefits our research agenda, as well as academia and industry after they graduate," said James Vary, physics professor at Iowa State University. "Two out of three of my graduate students came to Iowa State from abroad to earn their PhDs."

Vary was among a dozen APS members from across the country who met in their home states with congressional staffers representing their senators who sit on the Senate Judiciary Committee, which currently has jurisdiction over the Keep STEM Talent Act of 2019. They attended meetings in the offices of US Senators Thom Tillis (R-NC); Mike Lee (R-UT); and Chuck Grassley (R-IA).

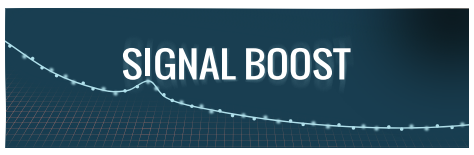
During the meetings, APS members shared experiences about long delays they've encountered trying to obtain green cards, after spending a considerable amount of time studying at US institutions. US-born scientists also informed the staffers about the benefits of working with international scientists. Additionally, APS members explained that it made sense for international students to keep their talent and skills in America, where they could contribute to the country that invested in them.

"We met with Carol Olson [Grassley's state director] and Adam DoBraska [Grassley's regional director] for more than hour, though we were scheduled for only half an hour. The meeting was very successful," recalled Vary.

Callie Pruett, APS Grassroots Advocacy Associate, said the APS Office of Government Affairs (APS OGA), was thrilled to help prepare the APS members for their meetings.

"The teams put in a lot of work. They participated in multiple team conference calls, honed their personal narratives and worked together to ensure that their meetings ran smoothly," she said, adding that the next goal is to work toward a bipartisan bill. US Senator Dick Durbin (D-IL) sponsored the legislation, which is currently co-sponsored by all Democrats.

STEM TALENT CONTINUED ON PAGE 6



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

White House Details Latest R&D Priorities

BY MITCH AMBROSE

The White House issued its annual R&D priorities memorandum to the heads of federal science agencies on August 30, offering them guidance as they prepare their budget request submissions for fiscal year 2021.

Many of the priorities restate or elaborate on ones articulated in last year's memo. For instance, it again promotes R&D underpinning "Industries of the Future," such as artificial intelligence and quantum information science. It also retains language favoring "early-stage" energy research over later-stage technology development and adds a new emphasis on nuclear energy R&D, including work on a proposed fast-neutron irradiation user facility.

Several entirely new priorities are included, such as research relating to "Earth system predictability," ocean exploration, critical minerals, high-risk high-reward research, and research integrity.

Following tradition, the memo is co-signed by the heads of the Office of Science and Technology Policy (OSTP) and the Office of Management and Budget, which is responsible for assembling the president's budget request for submission to Congress in February each year. However, this is the first memo the White House has issued since Kelvin Droegemeier's confirmation as OSTP director.

Droegemeier's influence is discernable throughout the document, particularly in its emphasis that the US research enterprise should uphold "American values," which are defined as encompassing "free inquiry, competition, openness, and fairness." The memo also incorporates the priorities of the newly established Joint Committee on Research Environments (JCORE), an interagency panel focused on topics such as combatting sexual harassment and securing research assets from undue influence or misappropriation by foreign governments.

The document elaborates on Droegemeier's conception of the enterprise as having entered a "Second Bold Era," which it states is characterized by not only its unprecedented opportunities, but also "new and extraordinary threats which must be confronted thoughtfully and effectively." Alluding to tensions within the research community over current research security initiatives, it states, "[Success] will depend upon striking a balance between the openness of our research ecosystem and the protection of our ideas and research outcomes."

Speaking to FYI, Droegemeier stressed that the work of JCORE is a top priority for OSTP and federal science agencies, saying that its Research Security Subcommittee, for instance, has met seven times since the panel was established in May and that "actionable" outcomes are forthcoming. "It's all hands on deck," he said.

Droegemeier highlighted the new section on Earth system prediction as a notable addition to the memo. It declares, "Knowing the extent to which components of the Earth system are practicably predictable — from individual thunderstorms to long-term global change — is vitally important for physical understanding of the Earth system, assessing the value of prediction results, guiding federal investments, developing effective policy, and improving predictive skill."

FYI SCIENCE POLICY NEWS FROM AIP

Droegemeier also drew attention to the memo's call for agencies to prioritize "transformative research of high risk and potentially high reward."

"We've got to be comfortable with failure on some of these big bets that we make. And I think, frankly, we've gotten away from that as a country," he said, attributing the shift away from such research in part to budgetary pressures that make grant reviewers more conservative in their recommendations.

Asked about the tension between the desire to increase support for high-risk, high reward research and the administration's past proposals to sharply reduce federal support for science, he said, "The key thing there is to have conversations about what the priorities are. Obviously, you would like to be able to do lots and lots and lots of things, and you can't do everything."

The author is Acting Director of FYI.

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INTERNATIONAL AFFAIRS

Jefferson Science Fellowships

BY R. J. (JERRY) PETERSON

The Jefferson Science Fellowship program (sites.nationalacademies.org/PGA/Jefferson) allows physicists and other science, engineering, and medical faculty with tenured positions at US universities and colleges to dedicate an academic year with the US Department of State (DOS) or the US Agency for International Development (USAID), working on a wide range of issues in scientific and technical issues among nations. I was a Jefferson Fellow in 2007–2008, working in the Office of Economic Analysis of the DOS and I was followed in that office by a string of JSF physicists. The DOS and USAID have a strong need for the critical thinking and judgement you possess.

The deadline for applications for the 2020–2021 academic year is October 31, 2019. The selection process is begun by your application, followed by an interview. Fellows will continue their university positions, with salary and benefits continued by a memorandum of understanding with your home institution, with a stipend of up to $50,000 paid by DOS or USAID. Washington is an expensive town. Applicants must be US citizens and a security clearance will be required. Upon arrival, the units of the DOS or USAID will present their cases and arrange for interviews. You will be expected to be available for JSF activities for a few years after the year in residence in Washington.

Jerry Peterson

One of the required application essays will ask you to specify how your home institution will benefit from your experience. I will be happy to discuss your applications (jerry.peterson@colorado.edu), and I am sure that other JSF alumni would also be willing to help. A list of these alumni can be found at go.aps.org/2mn6Kgd.

I found my year at the DOS to be highly satisfying, with my experience and background finding useful applications to new topics. One of the valuable sets of connections was with my fellow Fellows, a great bunch of men and women. And—it would surely be useful to be seen as a member of the APS Forum on International Physics (FIP), which you can join without cost as an APS member (go to aps.org/units/fip).

The author is Professor Emeritus in the physics department at the University of Colorado in Boulder and Past Chair of the FIP.

FEATURE

Preprints Make Inroads Outside of Physics

BY DANIEL GARISTO

In the years following World War II, a flood of research created a crisis for scientific communication. To keep up with the deluge, physicists began mailing unpublished manuscripts across the country and around the world. These preprints speedily brought research to physicists hungry for news, outstripping traditional publications by months. By the time Paul Ginsparg launched hep-th@xxx.lanl.gov (now known as arXiv.org) in 1991, paper preprints had been entrenched in the culture of physics for decades.

The success of arXiv, which now holds 1.5 million preprints, is well known to physicists, mathematicians, and computer scientists who rely on it. But similar efforts in other fields foundered. Life sciences repository *Nature Precedings* quietly shut down after six years and only about 2,000 preprints; the Chemistry Preprint Server barely got off the ground. In many fields, journal editors refused to publish papers posted as preprints.

Recently, however, the tide has begun to shift. Since 2013, dozens of preprint servers in fields such as biology, chemistry, and sociology have popped up and garnered tens of thousands of submissions.

In 2017, the National Institutes of Health allowed the inclusion of preprints in grant proposals. In May, the *Nature* family of journals announced that it would move from allowing preprints to encouraging them, now allowing researchers to speak to the media about preprints of submitted manuscripts. And on June 25, Cold Spring Harbor Laboratory (CSHL), Yale University, and the journal *BMJ* launched a new server for medical preprints, medRxiv.

For most physicists, scholarship without preprints is foreign. But working with preprints can be just as alien to scientists in other disciplines. "I still encounter people who don't know what a preprint is," said Jessica Polka, a biochemist and executive director of ASAPbio, a nonprofit focused on faster, transparent publishing in the life sciences.

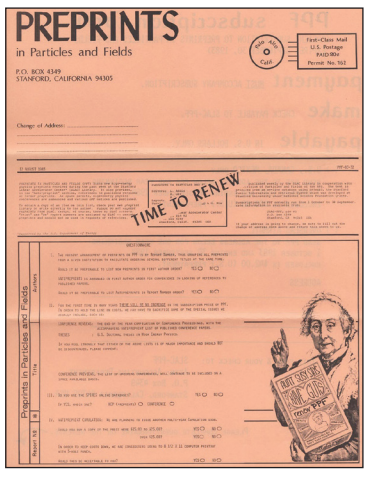
Fields other than physics have some catching up to do. Only one to two percent of the nearly 30 million peer-reviewed articles in PubMed, a life science aggregator maintained by NIH, initially appeared as preprints. As of 2009, over 95 percent of articles published in peer-reviewed HEP journals also appeared on arXiv.org. This discrepancy didn't always exist—at one time, fields like psychology and biology also used preprints.

Dealing with a Deluge

Throughout the 1960s, multiple organizations across various disciplines attempted to scale up the private, informal sharing of preprints that had grown in previous decades. In 1961, the American Psychological Association began a short-lived experiment in preprint exchange to solve the issue of publishing lag. The association found that "those who need preprints most—young scientists, workers at small institutions, and researchers in less developed countries—are frequently not the recipients."

At the same time, the NIH formed its Information Exchange Groups (IEGs), which ballooned from 32 biologists in 1961 to 3600 in 1966. But in 1967, the IEGs were abruptly terminated. A 1966 *Nature* editorial enumerated a list of growing problems, concluding that "the experiment was plainly on the point of getting out of hand."

Rita Taylor helped run Preprints in Particles and Fields (PPF) at SLAC for many years. IMAGE: SLAC



August 12, 1983 issue of PPF mailed out from SLAC. Each issue contained a list of that week's preprints. IMAGE: SLAC

While the IEGs certainly faced organizational problems like the cost of mail ($400,000 then) and confidentiality, their biggest impediment came from journals like *Nature* itself. Wary of the IEGs' popularity, editors of biochemical journals were happy to recognize the value of IEG memoranda—so long as it was clear that the material was never to be published. Two years later, this anti-preprint stance spread across scientific publishing thanks to what became known as the Ingelfinger rule (see *APS News*, November 2012).

During the early 1960s, preprints, especially in HEP, had proliferated out of control. In 1965, theoretical physicist Michael Moravscik proposed an analogous "Physics Information Exchange" (PIE) to tame and centralize the chaos. Similarly, *Physical Review* editors like Sam Goudsmit and Simon Pasternack voiced opposition. In an acerbic editorial entitled "Communication Problems," Goudsmit mocked preprints:

"The next step might be to equip theorists with portable recorders so that all their statements about physics, including those uttered in their sleep, would be preserved on tape. The contents of the tapes would be transmitted electronically to interested colleagues via a distribution center. Hopefully, such a system might result in such chaos as to make priority assignments impossible, and the great advances in theoretical physics would become anonymous, just like the great achievements in the art of ancient Egypt."

But thanks to funding from the US Atomic Energy Commission, the PIE launched as a trial run. Distributed weekly, the PIE cut costs by giving only a list of preprints, as opposed to providing the full document. Its success led to the SLAC-based *Preprints in Particles and Fields* (PPF). Until 1993, hundreds of physicists paid a subscription fee to get a weekly listing of preprints, delivered by airmail. To appease journal editors, PPF also contained a list of "anti-preprints," which were preprints that had been published.

Preprints Go Electronic

By the mid 1980s, networks like BITNET and DECnet connected physicists across the US and Europe, allowing them to access bibliographic information in databases like SPIRES-HEP. Math typesetting software like TeX and the development of email made it possible to share electronic preprints.

In 1989, Joanne Cohn, a physicist then at the Institute for Advanced Study, began distributing TeX files of string theory papers via email. By August of 1991, the email list had grown to 180 physicists—an unwieldy number for Cohn to individually respond to requests for papers. As Cohn recounts, a young physicist then at Los Alamos National Laboratory offered to automate the list, and arXiv was born.

"Day one, something happened, day two, something happened. Day three, Ed Witten posted a paper," said Cornell University physicist Paul Ginsparg, founder of arXiv.org. "That was when the entire community joined."

For physicists, it became indispensable. "It was this one-stop-shopping daily information feed. If it's not there, then it may as well not exist," Ginsparg said. "I still don't know if there's anyone that's using it quite like the high energy physicists were using it already in the early '90s."

Eager to capitalize on the phenomenon, the APS participated in "e-print" workshops and even launched its own ill-fated "e-print" server in 1996, which closed down within a few years. More successful was the groundbreaking decision by the APS in 1997 to amend its copyright rules, formally allowing e-prints. This reversal from anti-preprint attitudes of the 1960s was a testament to the cultural changes the past decades had wrought on physics and the inescapable power of the internet.

Jim Till, a biophysicist at the University of Toronto credits the adoption of arXiv to the fact that "HEP physicists have been members of a well-defined and highly interactive community of voracious readers, with a pre-existing hard-copy preprint habit, a standardized text formatting system (TeX), and a generally high degree of computer literacy."

In the decades that followed, as scientific publishing transitioned to the digital age, other preprint servers popped up. But few, if any, have replicated arXiv's success.

One of the most promising attempts was "E-Biomed," which then-NIH director Harold Varmus

PREPRINTS CONTINUED ON PAGE 7

FPS VIDEOS CONTINUED FROM PAGE 3

Frank von Hippel (Princeton University): Strengthening the Nonproliferation Regime

APS April Meeting in Denver

New Challenges International Science Collaborations

Amy Flatten (APS): Long-term Strategic Planning for APS International Activities

Bill Colglazier (AAAS): Opportunities and Challenges in International Scientific Collaboration on Large Scale Projects

Karla Hagen (British Embassy, Washington DC): The US-UK Science Collaboration Landscape: Status and Opportunities for the Future

Panel discussion: Challenges & Opportunities for International Science Collaborations

New Energy Technologies and Policies

Daniel M. Kammen (University of California - Berkeley): An Energy Plan the Earth Can Live With

Adilson Motter (Northwestern University): North American Power-Grid Network: Failures and Opportunities

Amory Lovins (Rocky Mountain Institute): Integrative Design for Radical Energy Efficiency

Attracting Young People to Science and Science Policy (with the APS Forum on Early Career Scientists)

Brian Jones (Colorado State University): Making Climate Change Concepts Accessible (and Acceptable) to a Wide Audience

David Maiullo (Rutgers University): Using Physics Demonstrations to Excite & Educate the Public in Science & Sci Policy

FPS Prize Session: Burton Forum Award

Shirley Ann Jackson (President, Rensselaer Polytechnic Institute): Physics, the River that Runs Through It All

Plenary Talks

Amory Lovins (Rocky Mountain Institute): Disruptive Energy Futures

Katie Mack (North Carolina State University): Physics and Social Media

The APS Forum on Physics and Society (aps.org/units/fps) addresses issues at the interface of physics and society as a whole. Your support is vital to the work of the Forum, both because FPS activities are coordinated by its active members and the financial support the Forum receives from APS depends on its membership.

LETTER CONTINUED FROM PAGE 2

Grove's interest in invention led to him specializing in patent law, including photography patent disputes, and unsuccessfully represented William Fox Talbot in a suit over his calotype patent. He was named a judge of the Court of Common Pleases in 1871 and was by most accounts a good and fair one. However, Grove was reportedly prone to become distracted by the technical minutiae of such disputes, peppering litigants with questions about how they might improve their inventions and occasionally suggesting improvements himself. He was knighted in 1872. Grove retired in 1887 and died at home in London nine years later.

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AI CONTINUED FROM PAGE 3

Neuronal activity in the brain generates detectable electrical signals at the surface of the brain; under normal conditions, the signals are relatively smooth and predictable, but during a seizure, these impulses become a chaotic electrical storm. Electroencephalograms (EEGs) measure this electrical activity and can indicate what state the brain is in.

Nemzer's group is using simulated EEG data, coupled with actual patient data, to train a deep learning algorithm—a type of artificial intelligence (AI)—to pick out neural patterns that indicate a seizure is coming on. During the training, EEG patterns are fed into the algorithm, which "learns" the difference between normal and epileptic brain recordings. The hope is that, when exposed to new EEGs from actual patients, the algorithm will report that a seizure is imminent well in advance.

"We've been using simulated neurons to generate data to train the model, the advantage with that being that it's easy to distinguish between the healthy functioning state and the seizure state," says Nemzer. "With machine learning, you need a lot of data, so we're combining actual patient data and simulated data to find the right patterns."

According to Nemzer, this concept of creating a device to sense seizures before they happen isn't new, but progress in machine learning algorithms have allowed the idea to become more realizable.

"People have been interested in this for many years, but it's resisted our best attempts at a seizure warning system, and the difference now is that the tools are so much better," says Nemzer. "A lot of progress has been made in terms of the ability of machine learning to make predictions even if the underlying physics is not completely understood."

Efficient machine learning algorithms are especially important for this kind of project because each device would need to be personalized for each wearer. The AI responsible for detecting the signals from the brain that indicate an oncoming seizure would need to undergo a training period to identify what constitutes a warning signal for each individual.

While this project is still in the AI training phase, Nemzer believes in its potential to positively benefit people with uncontrolled epilepsy.

"What got me interested in this topic is the fact that quality of life for people with epilepsy can be severely affected—often times they're not legally allowed to drive, or operate heavy machinery," says Nemzer. "Some people have suffered injuries or even death because of unpredictable seizures—I'm hopeful that this kind of early warning system would have a significant improvement in people's quality of life."

Additional Reading

L. Nemzer, "Treating Epilepsy with Physics," *Physics World* (September 2019).

STEM TALENT CONTINUED FROM PAGE 4

Pruett explained that highly trained STEM graduates are greatly needed throughout the US, especially in the states visited by APS members.

"In Iowa, there are 12,000 open STEM jobs; in North Carolina, there are 31,000; and in Utah, there are 6,000," she said.

Last year, a survey conducted by APS OGA of 49 of the largest graduate physics programs in the US revealed that the percentage of international students applying declined by an average of 12 percent from 2017 to 2018. In response, APS members worked with APS OGA to write op-eds and meet with congressional staffers, both locally and in Washington, DC, in an effort to persuade lawmakers to address the issue. Additionally, APS leadership has met with key officials representing various agencies, including the State Department, Office of Science and Technology Policy, Department of Energy, National Science Foundation, Commerce Department and Department of Defense.

To further probe issues related to visa policies, APS OGA recently partnered with the APS Office of International Affairs, the Forum on Graduate Student Affairs, and the Forum for Early Career Scientists to develop an anonymous survey to gauge the opinions of international graduate students and early career physicists. Nearly 700 international members responded to the survey.

One of the questions asked: "What specific issues did you run into while obtaining a student visa?" More than a quarter of respondents reported encountering challenges with obtaining a student visa. Among those issues included were time delays, expensive visa fees and difficulty proving intent to return to one's home country. Of those who reported having a time delay, 80 percent of them said the delay lasted more than one month.

Francis Slakey, APS Chief Government Affairs Officer, said information from the meetings, combined with the survey results, will be instrumental in helping APS OGA achieve its policy goals.

"We look forward to continuing to work with APS members, as well as developing surveys, to generate key data to keep APS in the forefront of addressing issues that are important to our membership," he said.

To show your support for the Keep STEM Talent Act, visit the APS OGA Advocacy webpage.

The author is the APS Senior Press Secretary.

CAM CONTINUED FROM PAGE 1

when first-generation stars and galaxies were forming.

Two more plenaries followed in the afternoon with speakers Zohar Nussinov (Washington University at St. Louis) and Karen Salomé Caballero Mora (Autonomous University of Chiapas). Nussinov spoke about his research in condensed matter, particularly the application of simple statistical mechanics and classical mechanics ideas to graph theory. Caballero Mora spoke about her involvement in the High Altitude Water Cerenkov Gamma-Ray Observatory (HAWC) and the supercomputer laboratory she is coordinating at Chiapas.

Parallel sessions took place between the plenaries in different classrooms, and the day finished with a dinner in the alumni hall. The parallel sessions included many topics: statistics, cosmology, philosophy, physics education, nuclear physics, quantum physics, condensed matter and materials, particle physics, physics in medicine and biology, and astrophysics.

On Friday, students had a choice between another tour of SNOLAB or attending the next plenary session, given by particle astrophysicist Jeter Hall, Director of Research at SNOLAB. Next came more parallel sessions and a mini-workshop on equity for gender and minorities in STEM. After lunch, Tonatiuh Matos (Centro de Investigación y de Estudios Avanzados del IPN) spoke about his dark matter research at the second plenary of the day. The plenary was followed by a panel discussion of science funding with tips on how to present a project to different agencies in order to get funding.

Next came the poster slam, which featured presentations from 35 graduate students. At the slam, a jury selected posters that would go on to contend in the poster competition. At the alumni hall, we had the opportunity to view the posters, and the jury selected the winners. To finish the day, we attended a banquet at the North Science Museum.

The conference closed with the plenaries of Eduardo Martínez, a neurophysics researcher who develops tools for understanding brain activity, and APS Careers Program Manager Midhat Farooq, who presented the career resources and opportunities available through APS, followed by a panel discussion about publications and closing remarks. Overall, it was a diverse conference, with a focus on interdisciplinary networking, which is an enriching experience for students.

The meeting organizers thank the following sponsors and partners for their generous contributions: Canadian Association of Physics, APS, Sociedad Mexicana de Física, Sociedad Cubana de Física, Laurentian University, SNOLAB, Perimeter Institute, Canadian Organizations of Medical Physics, Canadian Journal of Physics, TRIUMF, Science North, and the Sudbury local government.

Paloma Alejandra Vilchis León is a PhD student at Iberoamericana University at Mexico City, working in the areas of materials, nanoscience and nanotechnology. She is a member of the Sociedad Mexicana de Física and a contributor to "Random," a science radio program that is transmitted on Ibero Radio in Mexico City.

GIFT CONTINUED FROM PAGE 2

"The public needs to have a better understanding of the sciences," Oguz says.

APS programs that were demonstrated to improve science education such as PhysicsQuest and PhysTEC appealed to Oguz and Lord. Their goal is not in increasing the number of those going into the sciences, but getting the next generation of lawyers, legislators, and professionals to appreciate science.

"If you end up getting that exposure early on, then you don't dispute climate change [for example]," Oguz suggests. "It's very easy to develop very strong opinions either way, on both sides of the political spectrum. If you are ignorant about science, you can readily convince yourself that scientific theories and facts are just opinions that can be conveniently ignored or discredited."

The APS programs in education and diversity were the vehicle towards his and Lord's philanthropic goals. APS programs that support mentorship for the underrepresented students in physics programs were also attractive to Oguz and Lord as they believe in the importance of visible role models.

Oguz recalls that, as an undergraduate student at Bosphorus University in Istanbul, he didn't think twice about the fact that approximately half of his electrical engineering class were women as this was common and accepted.

Yet a few years later, in his first class at Harvard as a graduate student, he noted that of the 50 people in the auditorium only three were women, and very few, if any, were minorities. Oguz crossed paths with relatively few women and very few minority scientists throughout his career and met only one African-American physicist.

Oguz believes that, thanks to APS programs, the students selected from among their peers and supported towards higher education and a professional career can emerge as visible and alternative role models in their communities and help generate interest in science and an appreciation that science is in nobody's exclusive domain.

Having found exactly what they were looking for in the Education, Diversity, and Public Engagement programs at APS, Oguz and Lord arranged for a seven-figure estate gift to APS through the Legacy Circle program. They had a chance to speak with APS Director of Programs, Monica Plisch, who answered any remaining questions and assured them that their legacy was in good hands. He and Lord are confident that APS, their sole beneficiary, will foster education and inclusion for the next generation.

For information on joining the Legacy Circle or on how you can support the activities of APS, please visit aps.org/about/support/ or reach out to APS Campaign and Donor Relations Manager, Mariam Mehter at mehter@aps.org or (301) 209-3639.

PROGRAM CONTINUED FROM PAGE 1

because they don't realize how much teachers are paid—especially when compared to other jobs in physics—with prospects for good retirement benefits and high job satisfaction. Research done as part of the Get the Facts Out program indicates that teachers make $10,000 to $20,000 more than most people estimate, with mid-career teacher salaries ranging from $60,000 to $130,000.

"Get the Facts Out has been doing a lot of research to make sure we are comparing apples to apples," said May. "For someone with the same level of education, how much do you get paid in different careers?"

Their research found that high school science teaching is in the middle of the pack for starting salaries for graduates with a bachelor's degree in math, chemistry, and physics, with many variables that can lead to significant increases in income potential.

A further comparison between teaching and industry employment shows that teachers have excellent retirement prospects: While some private sector employees may earn higher salaries earlier in their careers, teachers often earn benefits and profit from public pension systems that allow for retirement security. Teachers in Colorado, on average, retire 15 years earlier than employees of Lockheed Martin, according to a Get the Facts Out study.

Teachers also report high job satisfaction, ranking second in a recent Gallup poll of dozens of professions. A four-year study conducted by the American Institute of Physics (of which APS is a member society) shows that high school teachers in both public and private schools reported similar job satisfaction and intellectual challenge to their private industry counterparts.

To dispel myths about teaching and hopefully recruit more high-quality science and math teachers, Get the Facts Out has launched a toolkit to reach university students, which is currently focused on those in physics departments. The program made its official debut at the PhysTEC conference in March and will be rolling out a larger marketing campaign this fall to reach beyond PhysTEC.

"Get the Facts Out has created resources for reaching students that include print resources, like posters, as well as entire PowerPoint presentations and interactive workshops," said May. "These resources are available on the website, but we also provide support for using these resources through a network of experienced faculty called 'change agents'."

According to May, more than 25 physics departments have already committed to using the resources provided by Get the Facts Out in the coming academic year and will collect data on the efficacy of the program.

"We're hearing a lot of interest in these resources—people are asking us about them and saying they want to use them," said May. "And we really seem to have hit a sweet spot in terms of what kinds of things faculty want and need to get the word out."

For more information, visit getthefactsout.org.

FOEP CONTINUED FROM PAGE 1

to public opinion surveys conducted by APS, people tend to have a high opinion of scientists but aren't sure that science has a big impact on their lives.

"People think of physics as what they saw in high school, dropping a ball and seeing how long until it reaches the ground," explained FOEP chair Don Lincoln (Fermilab). "Our challenge is to teach people that lasers and the transistor revolutionized the world, that the technology that makes the phone in their pocket possible is all due to advances in fundamental physics 50, 60, and 70 years ago."

Echoed Dahlberg, "People have lost sight of the scientific method and what it means. We need to educate the public about what science does, and its validity in the modern world."

So what are physicists to do? "Give a public talk," suggests Lincoln, "Start a science café. Write that book you always wanted to write. Start a blog. Run for office, if you have the stamina for it. Write an article for a public magazine or pen an op-ed. Chat with your neighbors, friends, and family."

FOEP vice-chair Shannon Greco, a science education program leader at Princeton's Plasma Physics Laboratory, underscored that science outreach is a fundamental duty of scientists.

"Having a scientifically literate society is essential for our survival as a society," she noted, "But for people to be interested in STEM, you need to reach out to them."

She further argued that from a taxpayer perspective, scientists have a responsibility not only to deliver on publicly-funded research projects, but to inform the public how their money was spent, and in turn contribute to their understanding of science (and with it, greater curiosity and problem-solving skills).

"Any effort toward sharing the process of science gives people permission to use it in their own lives," she elaborated. "It's a tool for everyone, not just a collection of facts."

FOEP chair-elect Jim Kakalios (University of Minnesota) framed science outreach as a powerful and much-needed tool to foster more science-based decision-making in the public sphere. "Nowadays I fear that people hold the attitude that science is just another opinion," he said. "It is incumbent on some of us to make the effort to light a candle instead of curse the darkness and try to talk to the public. Not just as scientists but as citizens."

Outreach is not without its challenges. In Kakalios' view, the biggest hurdle in communicating physics isn't lack of interest but instead insecurity.

"A large part of the population is interested in science questions, but insecure about their ability to understand the material," Kakalios said. "If I do a bad job at explaining something to my colleagues they will ask me questions because they're confident in their knowledge. But this isn't the case for my next-door neighbor. The challenge is finding analogies that break through to people and ways of explaining physics that can be fun and engaging."

Greco highlighted lack of diversity as another challenge surrounding public engagement with physics.

"Out of all the sciences, physics and engineering have the lowest participation of women and minorities," she elaborated. "If the main image of a physicist is a white male, other people won't think physics is for them." Increased outreach from the existing women and under-represented minorities in the field is helping to counteract this. "It's working," she said, "but it's working too slowly." Notably, FOEP itself has among the highest rates of female participation for any APS unit (>25%).

Challenges aside, outreach has benefits for scientists themselves as well as the public. Sharper science communication skills translate to better grant applications, a stronger case when lobbying Congress for research funding, and wider public appreciation for one's own work.

It is unfortunate that the energy most physicists can dedicate to outreach is limited by the pressures of publication and securing grants, particularly for young faculty on the brink of tenure. To this end, Kakalios expressed hope that outreach could become more "professionalized" in the physics community.

"Being good at cutting through the noise is crucial. I would like to see outreach viewed not as 'dumbing down' the science but something that's important in its own right, just like devoting time and energy to being a really good classroom teacher is a laudable use of time and resources."

Added Lincoln, "perhaps one day strong contributions to physics outreach might be something a university would factor into the tenure decision-making process as a way to encourage young researchers at the peak of their career to continue sharing their excitement about science."

Overall, FOEP stands out as one of APS' most vibrant units, helping fellow APS members fine-tune the crucial skill of public outreach for the benefit of scientists and society alike. As Lincoln put it, "physics is far too much fun to keep it to yourself—share it far and wide!"

More information can be found at the FOEP website.The author is a freelance writer in Stockholm, Sweden.

PREPRINTS CONTINUED FROM PAGE 5

proposed in 1999. But after four months of opposition from journals, it was dead. The project lived on in PubMed Central, which archives peer-reviewed open-access articles in the life sciences, but no preprints.

"I shamelessly reused the same comment roughly every two years for over a decade: that it's thrilling that biologists are finally entering the latter half of the 20th century, better late than never," said Ginsparg. "And, of course I could reuse it because it never actually happened."

Making the Case for Preprints

A number of fears and concerns link these failed ventures. In fields such as biomedicine, researchers are often wary that unrefereed papers could have serious public health implications. Though preprint advocates believe the concerns are overstated, the worries still exist and have led to extremely careful rollout of medRxiv, which claims to have instituted stringent acceptance criteria.

"There's a huge variety in how rigorous peer review is and papers people really want to get published probably will anyway," said Polka. "I'm not sure eliminating preprints is going to fix that problem."

While physicists consider a preprint as a stamp of priority, many scientists in other disciplines worry that posting a preprint will cause them to be scooped. There is little evidence of such scooping so far, but the fears still persist.

"If you're doing something off of a big data set that anybody has access to, and you put a preprint out, it's not totally clear that somebody is going to respect that," said Elizabeth Berman, a sociologist at the University of Albany and a member of the SocArXiv steering committee.

SocArXiv was established in 2017 and hosts over 3,000 papers, but is still not used widely by the sociology community, despite the fact that adjacent fields of research use the Social Science Research Network (SSRN) and economists have long posted preprints to the National Bureau of Economic Review and the online repository RePEc since 1997. Academic communities unfamiliar with preprints and rarely exposed to preprint culture didn't develop it; those that accepted preprints never looked back.

Outside of a few exceptions, the majority of preprint servers have popped up within the past few years. One of the first of this new wave, bioaRxiv, was founded in 2013 with the support of CSHL and now receives over 2,000 preprints every month. Then, an explosion of servers followed: ChemrXiv, engrXiv, SocArXiv, LawrXiv, SportrXiv, PaleorXiv, and regional hubs, like AfricArXiv and IndiaRxiv. Thanks to easily available software from the Center for Open Science, building the infrastructure for a preprint server is no longer an obstacle.

Looking at bioaRxiv as a case study, Till points to a number of important reasons for its growth, including its backing by CSHL, the concomitant rise of quantitative biology submissions to arXiv, and a cultural shift in biology toward openness and transparency.

Still, bioaRxiv and other new preprint servers are far from having complete community buy-in, like arXiv did. "I would say it's far from being successful at this point," said biologist Jon Inglis, the co-founder of bioaRxiv. "But it clearly has momentum."

At various times in the history of preprints, their advocates and detractors have predicted that preprints would spell the end for traditional academic journals. Both sides have been repeatedly proven wrong on this matter: preprints have managed to largely coexist with traditional journals, which still fulfill the important task of quality control and curation. As they continue to expand in other fields, preprints may soon find themselves as much a fixture of publishing as they have become in physics.

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

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Proving Einstein Right: Prologue

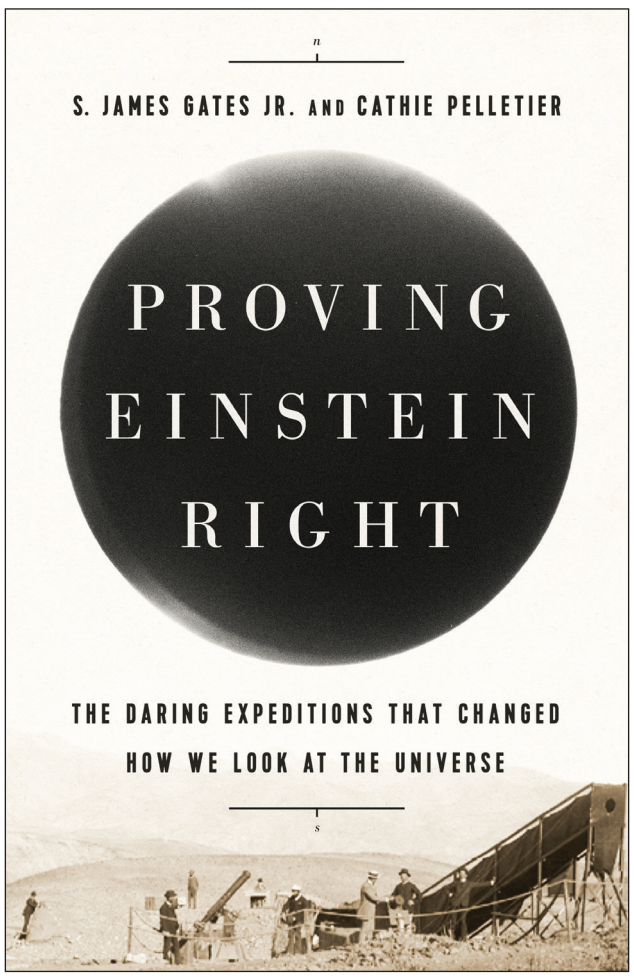
BY S. JAMES GATES JR. AND CATHIE PELLETIER

I must search in the stars for what is denied me on earth.
—Albert Einstein

You are standing in the path of totality, waiting for a total eclipse of the sun. You have never witnessed one before, but each is different. It happens slowly, as if giving your brain time to prepare as the shadow of the new moon speeds forward to devour our closest star. At first contact, it looks as if a dark mouth has taken a bite of yellow from the sun. But this is still your world, the one you have known all your life. The bite grows larger as more of the sun disappears. With ten minutes to second contact, the total eclipse, daylight has gradually slipped away, replaced by a bluish twilight. The once magnificent sun has been eaten down to a thin crescent. Familiar landmarks now exist in a world of monochrome color you do not recognize. Odder things begin to happen. Reflected through the leaves of nearby trees, thousands of small images of the sun's crescent are spilled on the ground around you. Animals have sensed the loss of daylight. Birds flutter in confusion. Cows herd into the barn. Nighttime insects rattle in surprise. Diurnal flowers fold their petals. A shivering dampness flows over you. At your feet, the grass has turned to silver. This is no longer the earth you knew.

Now the sun has become a thin sickle, clinging to its last rays of light. The moon's shadow comes quickly from the western horizon, a massive wall of darkness speeding toward you at over two thousand miles per hour. With totality soon to begin, the crescent of sun breaks into blazing beads of light that flow into each other, like drops of water fusing, until only one bead is left. It glitters in the darkened sky above you like a diamond ring. Jets of red flame burst from behind the black body of the moon before it finally covers the sun, the source of life for your planet. Songbirds are silent. Bats are on the wing. This is when you can look with your unprotected eyes at the spectacle above you. Planets that were lost in the light of daytime are now visible. The brightest stars twinkle. The solar corona, shimmering like a milky halo around the sun's hidden disc, is the color of liquid pearls. Its gray-white streamers, laced with crimson, are spilling backward into space for millions of miles. Your world has been thrown into a dreamlike trance. Distance now has no meaning. The heavens reach down, bringing the universe closer. The vastness of space reminds you of your mortality.

But now the reverie starts to undo itself, slowly reversing its steps. The diamond ring is back, a pulsing bead. It soon blends into a glowing string of pearls. The moon is gradually uncovering the sun, which has not perished after all. There's the crescent again, a blessed slice of yellow. The planets and stars have disappeared. Songbirds begin singing from the trees. The air around you warms as the sky once again lightens. The life-giving sun is on its way back. The world you thought you knew is returning. But it will never be the same one you left minutes earlier. You are now changed. You have been transformed by the magic and the miracle of a total eclipse of the sun.



Although the astonishing splendor of a total solar eclipse has never changed, what *has* are the people who view one. If you live near or within the path of totality, you're just plain lucky. While professional astronomers and experienced amateurs will travel great distances around the world for a total eclipse, even the casually curious can become eclipse chasers, especially within their own country. They catch planes or they drive to that slim track where the view will be perfect, despite the fact that totality may last only a couple of minutes. Days before an eclipse, airports become crowded, car rental companies are besieged, and hotels fill up. Professional tour packages headed by seasoned astronomers are fully booked months in advance by teachers, bank tellers, college students, and doctors.

Eclipse day is filled with news coverage, commentaries, and precautionary advice. Enthusiasts can check up-to-the-minute weather reports and track the path of the sun on their phones and iPads. If the viewing place they chose has clouded over, the more ambitious jump into cars or onto tour buses and speed to another spot, fifty or a hundred miles away, where the skies are cloudless. Wealthy eclipse chasers purchase seats on chartered jets that fly them above any inclement weather as they follow the moon's shadow. In June 1973, a select group of astronomers chased the eclipse path across the Sahara Desert at twice the speed of sound in an early model of the Concorde. In 2017, the National Aeronautics and Space Administration (NASA) sent out two jets with telescopes mounted on their noses, maximizing the minutes they could photograph the eclipse during totality.

But it wasn't always this easy. From the mid-1800s into the first two decades of the 1900s, long-distance travel to eclipse paths was mostly done by professional astronomers and knowledgeable amateurs. These men of science, and the rare women of science, were unwavering in their desire to observe a total eclipse of the sun for those few brief minutes. Lured by this remarkable phenomenon, they planned for months and even years before journeying to exotic parts of the world. Travel by boat, train, wagons, and pack animals was always rigorous and often dangerous. And yet, their best-laid plans could be obliterated in seconds by rain or clouds. The outbreak of regional or national conflict could entirely undo a well-planned expedition. Gone from their families for months at a time to foreign lands and unforgiving climates, these astronomers faced illness and possible death from the bubonic plague, malaria, yellow fever, and the Spanish flu. They protected themselves as best they could from wild animals, poisonous snakes, venomous insects, floods, forest fires, food poisoning, and local superstitions. But through it all, their mission remained clear: advance scientific research to better understand the cosmos.

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Until the last years of the nineteenth century, drawings by sketch artists using pencils, charcoals, and pastels had been the dominant method of capturing images during a total eclipse. As photography evolved and became more sophisticated, it soon replaced drawings, which had to be done quickly. Photographic plates were permanent records that could later be reviewed and analyzed. But until 1911, astronomers were focused mostly on solar-related features during eclipses, especially on the corona, that halo of matter surrounding the sun. From this coronal structure, which could only be observed during totality, they would learn much about sunspot cycles, solar flares, and the solar atmosphere itself. Their attention during these eclipses, therefore, was on the sun, our own star. Other stars were studied at night, in observatories and with amateur telescopes around the world. And then along came a young German physicist with a challenging question about photographing other stars during a total eclipse.

Before he turned thirty, Albert Einstein had been working on a geometric theory of gravitation that embraced his 1905 theory of special relativity and expanded Newton's law of universal gravitation. Commonly known as general relativity, the theory provided a provocative and unified description of gravity as a property of space and time, what would become known as *space-time*. The curvature of space-time would be linked to the energy and momentum of any existing matter and radiation. If this idea was correct, the path of light would follow the arc of space-time. Thus, when passing close to a large body or mass, light would bend by an observable amount. But how to prove it? It was obvious to Einstein that his answer lay in those large bodies of the cosmos, a planet or star big enough to attract light waves. A physicist, he now needed the help of astronomers. The only way to test this premise would be to photograph starlight as it passed the gravitational pull of the sun. And the only time that could be achieved was during the brief darkness of a total eclipse.

Over the course of a decade, several esteemed astronomers in four countries would take on the "Einstein problem" in what would become an epic tale of frustration, faith, and ultimate victory. To succeed, at least one of them would need access to the path of totality for an upcoming eclipse. He would need ample funding. He would need the proper instruments. He might have to travel thousands of miles. He would hope for unity in a world that often perched on the brink of war. And he would pray for clear weather during those few fleeting minutes. If all these elements came together, the answer he found in the stars could shake the foundations of physics that had been in place for two centuries. The very concept of gravity, as the world understood it from Sir Isaac Newton, was at stake. Would the apple fall in a new way?

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This article is excerpted from their new book Proving Einstein Right: The Daring Expeditions that Changed How We Look at the Universe *(PublicAffairs, Hachette Books Group, 2019).*