January 2020 • Vol. 29, No. 1
aps.org/apsnews

APS NEWS

A PUBLICATION OF THE AMERICAN PHYSICAL SOCIETY

Meet the 2020 APS Presidential Line

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The APS Presidential line is elected by the entire membership and consists of four persons, who rotate through one-year terms as Vice President, President-Elect, President, and Past President. These four members all began their new roles on January 1, 2020. For more on APS governance visit aps.org/about/governance.

GOVERNMENT AFFAIRS

Partnering with APS Members in 2019 to Advance the Scientific Enterprise

BY TAWANDA W. JOHNSON

The APS Office of Government Affairs (APS OGA) worked with Society members throughout 2019 to successfully advocate for physics and physicists and to amplify their voices for science. APS OGA facilitated more than 2,500 APS member contacts through op-ed placements, congressional letters, and both local and DC visits with congressional offices from key states and districts to advance the interests of the physics community.

"APS OGA is thrilled to have worked again this year with APS members who were eager to do their part to make a difference in science policy initiatives that impact the physics community," said APS Chief Government Affairs Officer Francis Slakey.

Staff members from the APS Editorial Office in Ridge, NY, recently visited Capitol Hill to advocate for the Keep STEM Talent Act and urge action against EPA rollback of methane emission regulations (L-R): Dario Corradini, Robert Wimmer, Matteo Rini, Katiuscia Cassemiro, and Roslie Barreto.

Throughout 2019, APS OGA surveyed APS members at meetings to determine the issues that concerned the physics community, and APS OGA developed strategies to respond to those needs.

Federal Research Funding: In an ongoing effort to achieve sustained and robust support for federal science agencies, APS OGA worked with APS members and coordinated with other science and technology organizations

PARTNERING CONTINUED ON PAGE 7

MEMBERSHIP UNITS

APS Launches a New Forum on Diversity and Inclusion

BY LEAH POFFENBERGER

On November 8, the APS Board and Council approved the creation of a new forum dedicated to making physics a community where all people feel welcome and heard. A petition to create the Forum on Diversity and Inclusion (FDI) received over 1600 signatures, blowing past the 200 signatures needed for the Council's consideration, and the petition received a unanimous vote of approval from the Council.

A key tenet of the *APS Strategic Plan: 2019* is serving the physics community by providing a welcoming and inclusive environment for all those engaged in physics, and FDI is an integral step to meeting this goal. The formation of FDI will both supplement and expand existing efforts by APS and its member units to promote a culture of diversity, equity, and inclusion in physics, as it will be able to bring together APS members from a variety of backgrounds. FDI will grow the number of APS members who are involved in diversity and inclusion efforts, provide a space for discussing issues within the physics community, and support existing projects.

Elizabeth Simmons

"The creation of this forum is very timely as the portfolio of APS diversity programs has grown substantially over the last few years," says Monica Plisch, Director of Programs at APS. "For example, the new APS-IDEA project will network and support physicists working to improve diversity, equity, and inclusion in their physics departments and laboratories, and the Forum is a natural partner in this effort."

APS committees, such as the

FDI CONTINUED ON PAGE 5

STRATEGIC PLAN

APS Makes Progress on Priorities

Throughout 2018, APS members, leadership, and staff prepared a new Strategic Plan to guide the Society and lay out priorities for APS in the years ahead. Strategic planning is an opportunity to set priorities, focus resources, work toward common goals, and assess and adjust the Society's direction in response to a changing environment.

"I don't see strategic planning as a tactical exercise but as a process that will lay out options, strategies, and rationales so that APS can remain a strong advocate for physics in a changing environment," said 2018 APS President Roger Falcone.

This process involved the Strategic Planning Steering Committee, APS Board of Directors, APS Senior Management Team, staff, and volunteer leaders working with a consultant to bring in stakeholders and stay at a consistently high level. Outreach to membership included discussions at the APS Leadership Convocation, Town Halls at APS March and April Meetings, Focus Groups at March and April Meetings, presentations at the APS Annual Business Meeting, and an online feedback form.

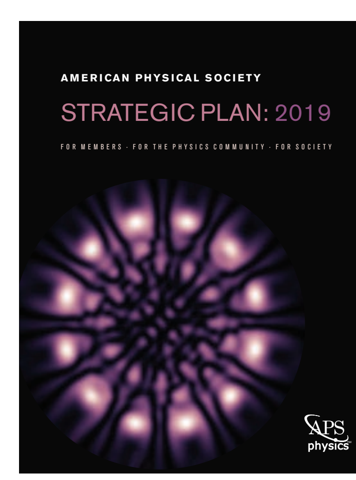
The result has been a dynamic, nimble plan that is easy for everyone to understand, a document that is an active guide for APS to respond to opportunities and challenges. *The APS Strategic Plan: 2019* will be used to communicate the organization's goals, potential actions, and metrics for measuring success and impact, both internally and externally. The plan document can be downloaded at go.aps.org/strategicplan.

"I am very impressed by the efforts of the staff and the Board and all the committees who put in an incredible amount of work and completed the plan on schedule," said 2019 APS President David Gross. "We want to improve current operations and build on what APS has always been doing and doing well, to doing it even better. Given my limited time as President, I have focused on implementing some of the newer initiatives, especially the Innovation Fund and a new annual meeting."

Added APS CEO Kate Kirby, "APS has a tremendous amount to be proud of in terms of the things the Society does for and with the physics community. It is important for us to continue doing those things but also to explore, experiment, and pilot new ways to move forward."

Here are some of the important accomplishments thus far:

APS Innovation Fund: The APS Innovation Fund was launched in early 2019 to inspire members to develop fresh approaches to serving the physics community in ways aligned with the Strategic Plan. Four projects were selected for funding (see *APS News*, August/September 2019): improving the APS meeting experience through machine learning; the APS Inclusion, Diversity, and Equity Alliance (APS-IDEA) to create



a network of diversity leaders; informing and activating the US physics community to tackle nuclear proliferation issues; and the US-Africa Initiative in Electronic Structure to foster collaborations between African and US physicists. The APS Board and Council voted in November to continue the Innovation Fund in 2020.

APS Ethics Committee: A new Ethics Committee, which convened for the first time on June 6, 2019, will lead the charge for promoting ethical practices by APS members (see *APS News*, July 2019). The committee chair for 2019-2020 is Michael Marder (University of Texas at Austin). Among the committee's many roles will be development and review of ethics policies for APS; procedures for handling complaints and potential revocation of honors; creating materials to educate members in best practices; and organizing

PLAN CONTINUED ON PAGE 6

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EDUCATION AND DIVERSITY NEWS

Wiki Scientist Course

You are invited to join APS and Wiki Education (WikiEdu.org) to discover new ways to help break barriers for underrepresented groups in the sciences. With approximately 500 million views a month, Wikipedia is one of the most popular and best-known websites in the world. However, you may be surprised to learn that fewer than 18 percent of the biographies on the site are about women. APS encourages you to take an active role in raising that percentage. Give a voice to the voiceless and impact your field by applying to take our Wiki Scientist Course, *Biographies of Women and Minority Physicists*. Act quickly—the application closes on **January 10**. Apply here: aps.org/programs/outreach/wiki-course.cfm

MEETINGS

Jupiter's Great Red Spot Should Keep on Spinning

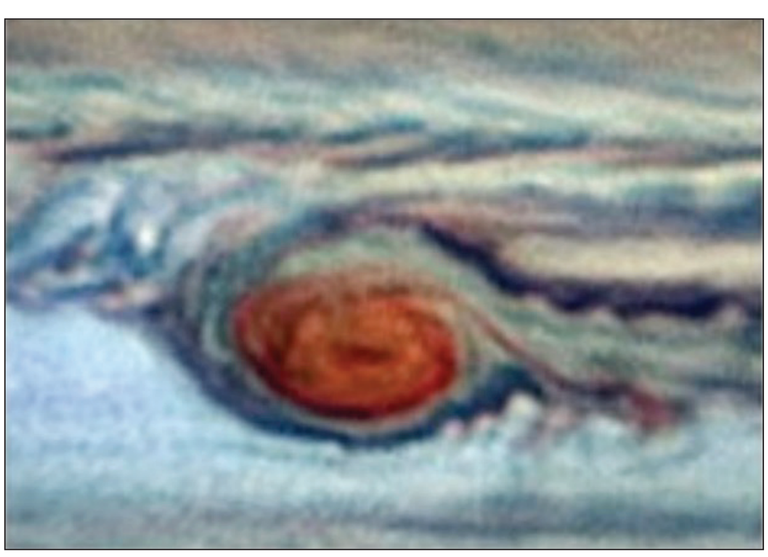
BY LEAH POFFENBERGER

In late 2018, astronomers started observing something weird about Jupiter's famous Great Red Spot: It appeared as if large red flakes were being ripped off the planetary feature, leading to predictions that it would disappear within the coming decades.

Philip Marcus from the University of California, Berkeley, hopes to reassure worried fans of the Great Red Spot with research he presented at the 2019 Division of Fluid Dynamics Meeting in Seattle, Washington. Work done in his lab shows that beneath the swirling red clouds, the vortex that powers the Great Red Spot is still going strong and that the observed flaking was a result of interactions with smaller vortices.

Most of the images that astronomers, both professional and amateur, were viewing during the flaking phenomenon actually show the cloud layer on top of the Great Red Spot, and according to Marcus, the clouds don't always give an accurate description of the

JUPITER CONTINUED ON PAGE 7



A (false color) image showing the flaking of red clouds from the Great Red Spot in the spring of 2019. IMAGE: CHRIS GO

THIS MONTH IN

Physics History

January 29, 1700: Birth of Daniel Bernoulli

Millions of people fly around the world with no thought about how airplanes can remain aloft. We owe the theoretical foundation of some of the principles of flight—among other fundamental insights—in part to a Swiss mathematician who made seminal contributions in fluid mechanics as well as probability, statistics, and vibrating strings.

Born in Groningen in 1700, Daniel Bernoulli had a powerful mathematical pedigree: he was the son of a mathematician named Johann Bernoulli, one of eight gifted mathematicians and physicists in the legendary Bernoulli family. They were a virtual dynasty during this period. The family originally hailed from Belgium but fled to Switzerland to escape Catholic persecution of Protestants. There, the family patriarch, Nicolaus (Johann's father, Daniel's grandfather), made his fortune as a spice merchant.

Nicolaus had intended that Johann take over the family business. Alas, Johann failed miserably as an apprentice and opted to study medicine at Basel University instead. He and his older brother, Jakob, began collaborating on the study of a shiny new mathematical tool called calculus and were among the first to apply it to various problems. When Johann switched from medicine to math, it ignited a nasty sibling rivalry that rippled through the Bernoulli family for decades.

The two brothers were highly competitive, fought constantly, and always sought to outdo each other when it came to posing mathematical challenges. The fact that Jakob had trained his younger brother made it difficult for him to accept Johann as an equal. Johann, in turn, hated to be out-done. When Jakob died of tuberculosis, Johann assumed his professorship at Basel University.

Even though Johann had rebelled against his own father's controlling behavior, that didn't keep him from treating his son the same way, selecting the woman Daniel should marry and insisting he should become a merchant like his grandfather. Daniel had no interest, so Johann insisted he study medicine instead. But Daniel's love and aptitude for mathematics did not subside, so eventually Johann relented and taught him the subject on the side.

After completing his studies, Daniel tried to get an academic position in anatomy or botany at Basel University, but these were typically decided by lottery, and he lost out both times. Italy beckoned for further medical training, and while there, Daniel invented a ship's hourglass capable of operating even in rough weather, winning a prize from the French Academy for his design. And he kept up his mathematical work, too, publishing his first treatise on the subject in 1724. *Mathematical Exercises* contained some early thoughts on the problem of pressure, inspired in part by his medical studies.

Upon returning home, Daniel received an offer to teach mathematics at the Imperial Academy in

Daniel Bernoulli came from a family of gifted mathematicians and physicists. IMAGE: WIKIMEDIA COMMONS

St. Petersburg, Russia. His older brother, Nikolas, accompanied him and took a similar position, but died of tuberculosis the following year. Without his brother, Daniel was increasingly unhappy in St. Petersburg and sought to return home to Basel. Instead, his father sent one of his best students, Leonard Euler, to Russia so the two could collaborate. It proved a successful partnership, producing work on the movement of strings in musical instruments, probability, and economics.

Daniel also did his most groundbreaking work on hydrodynamics during this period. The English physician William Harvey—who was the first to observe that the human heart worked like a pump to force blood through the arteries so it could circulate through the body—encouraged Daniel to combine his love for mathematics with his medical training to discover the basic rules that govern the movement of fluids.

One day he conducted a pivotal experiment: he punctured the wall of a pipe filled with fluid with a small, open-ended straw. He noticed that the fluid would rise up the straw, and the degree to which it would do so was directly related to the fluid's pressure in the pipe: the higher the pressure, the higher the fluid level would rise. His technique was soon adopted by physicians all over Europe, who used it to measure patients' blood pressure by sticking pointy glass tubes into the arteries, until a less intrusive method was developed some 170 years later.

Bernoulli went one step further and applied this discovery to his earlier work on the con-

BERNOULLI CONTINUED ON PAGE 4

APS NEWS

Series II, Vol. 29, No. 1
January 2020

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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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EDUCATION

CUWiP Positively Impacts Women in Physics

BY LEAH POFFENBERGER

Each year, around 2,000 undergraduate women in physics make their way to one of the many regional locations for the annual Conferences for Undergraduate Women in Physics (CUWiP). CUWiP began as a grassroots effort, launched by the University of Southern California in 2006, growing to six conference sites. In 2012, APS became an institutional home for CUWiP, providing support for a growing number of conference sites: from January 17 to 19 this year, 13 sites across the country will host women seeking undergraduate physics degrees.

CUWiP was founded with the goal of increasing the number of bachelor's degrees awarded to women. Just over 20 percent of bachelor's degrees in physics were awarded to women in 2017, compared to almost 35 percent of bachelor's degrees in all STEM fields. Through a weekend of plenary sessions, workshops, and networking events, CUWiP seeks to provide undergraduate women with a supportive community and tools they need to be successful in physics.

"Almost everyone who has a physics degree and is a woman will attend one of our CUWiPs. About 2,000 women each year are pursuing physics degrees and [we have] about 2,000 attendees each year," says Renee Michelle Goertzen, Senior Program Manager at APS. "We have a national reach."

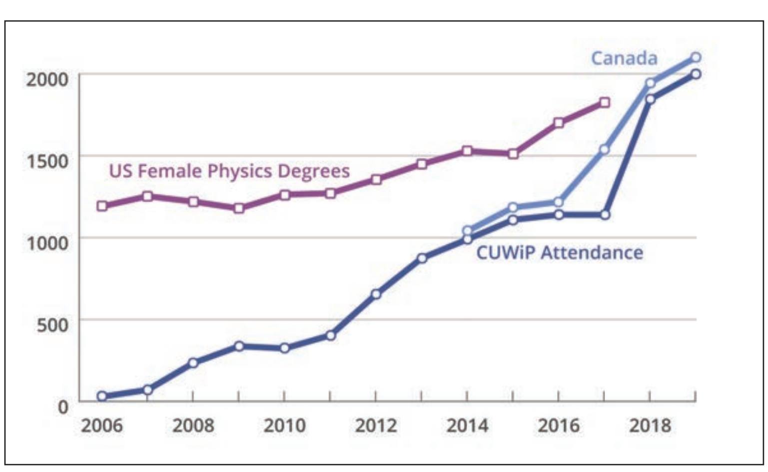
CUWiP indeed has a large presence, with twelve sites in the United States and one in Canada, providing geographic ease of access for many of the attendees. These conferences are also remarkably diverse, drawing in underrepresented minorities in physics. The percentage of students who are Hispanic, Black, or Native American and attend CUWiP is high compared with the number of physics degrees awarded. For example, Hispanic students make up 10 percent of awarded bachelor's degrees in physics and account for 22 percent of the 2019 CUWiP attendees.

"CUWiP is doing very well at attracting students from underrepresented groups, which is important because these are people who are coming from groups where they are probably less likely to see someone like themselves who is a physicist," says Goertzen. "It is extra important that they come to these conferences, meet other people who look and act and have interests like them so that they can say 'Oh, I could be a physicist!'"

Before and after each conference, attendees are surveyed by a team of physics education researchers on a number of areas, from knowledge about what they can do with a physics degree to measurements of persistence—the likelihood they stay in physics. Persistence is tied to a number of indicators, such as a sense of belonging in physics, identifying as a physicist, having others recognize you as a physicist, and being part of a physics community. After CUWiP, all attendee groups showed gains in persistence indicators, with women of color showing the largest gains on average.

Each CUWiP site's local organizers have the freedom to set their own conference agendas in order to

CUWIP CONTINUED ON PAGE 6



The number of women graduating each year with undergraduate physics degrees in the US is nearly equal to the yearly attendance at CUWiP conferences.

INTERNATIONAL AFFAIRS

Postcard: Physics in Vietnam

BY MICHAEL SCHIRBER

Note: This article—one of a new series—is reprinted from Physics Magazine *(physics.aps.org).*

On the coast of Vietnam, near the midpoint between north and south, sits Quy Nhon. In this city tucked within rolling hills, the locals go to the beach at the break of dawn before the streets fill up with the honking and puttering of motor scooters. It's here too where many scientists come to relax and attend meetings on particle physics, cosmology, and biophysics at the International Center for Interdisciplinary Science and Education (ICISE). Bordered by sandy beaches and coconut trees, ICISE hosts roughly 20 conferences per year. In September, I went to ICISE to attend a conference at the 15th Rencontres du Vietnam and to learn about the development of physics research in the country.

Established in 2013, ICISE owes its existence to Vietnamese-born, French-trained physicist Jean Trần Thanh Vân, well-known for organizing the yearly Rencontres de Moriond, a premier particle physics conference in the Alps. ICISE has recently added a small research institute in particle physics and will soon have a science museum and planetarium. "We are at the beginning of a long and exciting adventure," Trần Thanh Vân said in his opening remarks at the conference.

Aerial view of the conference center at ICISE. IMAGE: ICISE

Physics in Vietnam is also at a new beginning, one might say. The country endured decades of wars and economic turmoil, but the last 30 years have seen a new direction. Following the breakup of the Soviet Union, the country opened itself to the West. Its GDP has been growing at an average clip of 5 percent annually over the last decade, twice as fast as the US GDP. There has also been an uptick in investment for research and development both by the government and by industry. All this bodes well for the Vietnamese physics community.

In the past, physics has been in the shadow of other scientific disciplines. "We have a long tradition here in mathematics," Trần Thanh Vân explained to me. Well-respected mathematicians have come from Vietnam, including Fields-Medal winner Ngô Bảo Châu, and Vietnamese high school students perform well in international math competitions. By contrast, physics has lagged behind, in part because it's easier for universities to support a math professor than a physics professor needing experimental facilities.

"According to my memory, physics began to develop in Vietnam in the year 1956 when the department of physics was established at Hanoi University," said Nguyễn Văn Hiệu, who was the first director of

VIETNAM CONTINUED ON PAGE 5

MEETINGS

Putting the Flu in Fluid Dynamics: Tracking the Transmission of Airborne Disease Particles

BY LEAH POFFENBERGER

During the peak of flu season, many people find themselves being wary of their coughing co-workers or sniffling students, but airborne diseases, like cold and flu viruses, can sometimes travel far beyond a sick colleague's desk.

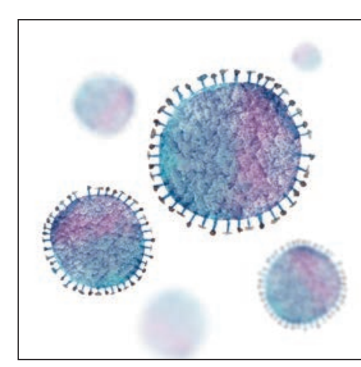
At the 2019 Division of Fluid Dynamics meeting in November, Sima Asadi from the University of California Davis presented research on tracking what activities cause a sick person to expel the most virus-laden droplets and modeling how these particles can spread in an indoor environment. Asadi's research, done as part of a partnership between the University of California Davis and the Icahn School of Medicine at Mount Sinai in New York, shows the disease-spreading potential of speaking loudly and provides a model for the spread of disease-carrying aerosol particles at various distances.

Coughing and sneezing are the two most obvious behaviors people think of when it comes to the spread of airborne diseases, since both give off large, easily visible droplets and a large number of microscopic particles—and both can carry pathogens. However, simply breathing and speaking can give off tiny particles capable of carrying infection, too. And since breathing and speaking can happen continuously, versus coughing and sneezing which happen more infrequently, it's possible these activities have a higher probability of disease transmission. Previous studies of infectious disease transmission have identified talking as a notable particle emission mechanism but did not account for differences in speech volume.

"[Other studies involved] counting from one to 100 and saying 'okay, we observed this much of a particle, so talking is important,' But we did a more controlled measurement: we controlled for the loudness of speech," said Asadi. "We performed more diverse activities and more importantly in our results, what we reported was the particle emission rate. We basically concluded that, whatever you say, if you speak louder, you will release more aerosol particles."

In addition to finding that speaking louder emits more particles, Asadi's research identified a subset of people who emit more particles while speaking in general, called "speech superemitters." This group consistently produced an order of magnitude more aerosol particles while speaking than their counterparts in the study, even after months had passed. Asadi's group is currently unable to say why certain people are so-called superemitters—age, gender, weight, and lung capacity don't seem to be factors—but knowing this subset of people exists could play a role in other disease transmission research.

"For influenza virus transmission, usually there are some people who infect more people than others, and we call them 'super-spreaders,' but [researchers] are unsure why those people are super-spreaders," said Asadi. "We introduced the hypothesis that some people might be super-spreaders because they are super-emitters."



Loud talkers spread more virus.

After establishing volume of speech as a parameter for aerosol emission and disease transmission, the next step for Asadi's research group was to use this data while examining the role of distance: what is the likelihood that someone in an enclosed space, like a classroom or an airplane, gets others sick through airborne particles?

Classical modeling of disease transmission has made use of what is known as the Wells-Riley model, which assumes all air in a room is perfectly mixed—meaning the aerosol particles are assumed to be part of that mixture. This fails to account for both time and location in the room, which limits the model's usefulness for short-

FLU CONTINUED ON PAGE 7

BERNOULLI CONTINUED FROM PAGE 2

servation of energy. According to Newton's laws of motion, a moving body exchanges kinetic energy for potential energy as it gains height. A similar phenomenon occurs with a moving fluid: it exchanges its kinetic energy for pressure. This is the Bernoulli Principle: the pressure of any fluid decreases where the speed of the fluid increases.

Daniel's research on fluid behavior culminated in his most important treatise, *Hydrodynamica*, published in 1738 after he had finally come home to Basel. Daniel organized the book around the notion of conservation of energy and included discussions of water flowing through a tube and from a hole in a container. It explained hydrodynamic pressure and described various hydraulic machines. He also provided a foundation for the kinetic theory of gases, applying the concept as a means of illuminating Boyle's law.

Despite Daniel's success, or rather, because of it, his relationship with his father continued to worsen, coming to a head in 1734, when both Daniel and Johann submitted winning entries for the Paris Academy's Grand Prize, and were jointly awarded the honor. A jealous Johann was furious, banning his son from his house—how dare the student be deemed the master's equal!—oblivious to how his bad behavior mirrored his late brother's jealousy of him.

Johann went so far as to publish his own book on hydrodynamics in 1739, one year after the work of his son, but deliberately predated it to 1732 in order to claim credit for Daniel's work. Their relationship never recovered from the insult, and a dispirited Daniel never quite showed the same enthusiasm for his mathematical studies after the rift.

Yet Daniel continued to contribute to various different fields for the remainder of his life, such as the study of the oscillation of air in organ pipes. He was elected as a fellow of the Royal Society and won the Paris Academy's Grand Prize nine more times. He died on March 17, 1782, his scientific legacy assured.

GOVERNMENT AFFAIRS

APS Opposes Administration's Proposed Rule on Methane Emissions

BY TAWANDA W. JOHNSON

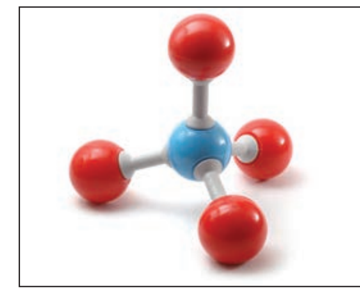
In response to APS members' concerns about climate change, the Society recently submitted a public comment (go.aps.org/32Kp16w) opposing the EPA's proposed policy amendments to curtail regulation of greenhouse gas emissions. The amendments would eliminate requirements on oil and gas companies to install technologies to monitor methane leaks in pipelines, wells, and storage facilities. APS urged the EPA to instead carry out a rigorous assessment of methane emissions—a major contributor to climate change.

"Public policies related to climate change are top concerns of our members. Recent science is now showing that the environmental impact of methane emissions on global climate change is worse than past estimates. We are directly opposing the administration's proposed rule change relaxing methane emissions, and we are doing so based on the science," said Philip Bucksbaum, 2020 APS President and a physics professor at Stanford University and SLAC National Laboratory.

APS previously encouraged members to submit their own comments on the proposed amendments by EPA's November 25 deadline.

According to the APS comment, "until recently, widely used calculations of methane's radiative forcing (RF) had excluded any short wavelength effects. This omission has led to a systematic underestimation of methane's RF by approximately 15 percent. Additionally, the inclusion of short wavelength effects impacts methane's 100-year global warming potential (GWP), increasing it by 14 percent above the value currently provided by the Intergovernmental Panel on Climate Change."

Furthermore, the APS comment stated: "With the risks of methane

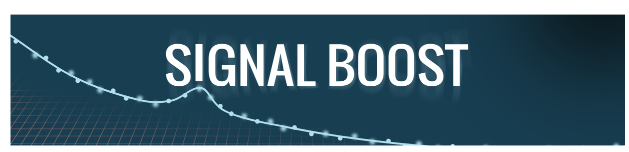


emissions now determined to be higher than previously estimated, this is not the time to be relaxing regulations."

Interestingly, major oil and gas companies have previously made statements supporting the regulation of methane emissions, including BP America Chairman and President Susan Dio, who outlined the company's stance in an op-ed in the *Houston Chronicle* (March 27, 2019). She wrote,

"First, it's the right thing to

METHANE 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 Revives Science and Technology Council

BY WILLIAM THOMAS

The President's Council of Advisors on Science and Technology (PCAST) had stood dormant for more than 33 months when President Trump signed an executive order reconstituting it on October 22. Comprising eminent outside experts, the role of the council is to provide independent advice to the president and White House policymakers.

Every president has stood up their own version of the council since George H. W. Bush first established his in 1990. Before that, most other presidents employed analogous bodies, dating back to Dwight Eisenhower's creation of the President's Science Advisory Committee in 1957 after the Soviet Union launched its Sputnik satellite.

So far, Trump has named nine of an anticipated 16 members. Of them, three are academics, including Birgitta Whaley, director of the Quantum Information and Computation Center at the University of California Berkeley. Council members from industry include Dario Gil, the director of IBM Research, and A. N. Sreeram, the head of R&D at the Dow chemical company.

PCAST will be chaired solely by Kelvin Droegemeier, director of the White House Office of Science and Technology Policy and the council's ex officio 17th member. Past iterations of the council have also drawn a co-chair from among its ordinary members, but that does not appear to be in the plans for the current version.

At PCAST's first meeting on November 18, Droegemeier emphasized that, with only about a year remaining in the current presidential term, time is of the essence. He said the council will not produce detailed reports, as previous presidents' councils have, but rather will focus on making more immediately "actionable" recommendations. He also said its efforts will focus on what he referred to as three "priority workstreams."

The first workstream revolves around five "Industries of the Future" that OSTP identified earlier this year as priority R&D areas: artificial intelligence, quantum information science, 5G telecommunications, advanced manufacturing, and synthetic biology.

The White House has tasked the council with developing a "five-year plan" for accelerating the development of these industries that includes immediate, short-term recommendations. Droegemeier suggested the plan could focus on overcoming obstacles that inhibit collaboration across the academic, industrial, government, and nonprofit sectors of the US research enterprise. He characterized such an initiative as "much more than a pilot, it actually is an experiment at scale."

A second workstream entails better leveraging federal laboratories to benefit the enterprise. At the meeting, conversation about the Industries of the Future dovetailed with discussion about how the labs could better advance them.

Speaking to the council, Department of Energy Office of Science Director Chris Fall emphasized that DOE's national labs have substantial authority to build cross-sector relationships. He added there is already considerable interest in using the labs to build partnerships but noted that new initiatives can tax the capacity of the administrative officers responsible for implementing them.

The third workstream involves bolstering the US STEM workforce. Although the council did not decide how they would approach the issue, they discussed a variety of problems such as recruiting and retaining a diverse community in STEM fields, bolstering the skilled technical workforce, and upskilling workers to adapt to technological and economic change. They also broached the possibility of looking at US visa practices and other issues related to retaining foreign talent in the US.

Droegemeier said that, to elevate attention to issues affecting younger people, this version of PCAST will include for the first time a subcommittee comprising 20 individuals at the student, postdoctoral, and early-career levels.

PCAST has tentatively scheduled its next in-person meeting for February 2020.

The author is the Senior Science Policy Analyst at FYI.

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FDI CONTINUED FROM PAGE 1

Committee on Minorities in Physics and the Committee on the Status of Women in Physics, have long been addressing diversity and inclusion issues. Committees comprise smaller groups of appointed APS members who oversee and support programs related to their charge, while forums are larger membership units that any APS member can join. Several APS Divisions, like the Division of Nuclear Physics, also have initiatives for diversity and inclusion, but FDI hopes to be a more centralized mechanism of promoting these aspects of physics.

"We have committees that do a lot of diversity work for APS, but they are smaller groups: for example, the APS committees have just nine people. There's only so much that they have the capacity to do," says Erika Brown, APS Education and Diversity Programs Manager. "I think there was a need for a larger membership group to be able to spread the workload, build on the groundwork other groups have laid in order to tackle larger things, and ideally have a greater impact on diversity within physics."

Elizabeth H. Simmons, the organizing committee co-chair and Executive Vice Chancellor of Academic Affairs at the University of California San Diego, stressed the need for a space that promotes discussions of intersectionality—both of identities and physics subfields.

"Each person has a set of different sub-identities, and it's the combination of all those different things that impacts how you interact with society. To be most effective, APS needed some way of addressing the full spectrum of what people might be experiencing, not just limited to being a woman or being LGBT or being a racial or ethnic minority," says Simmons. "We looked at the available types of [membership] units and [a forum] seemed the best match: It would be member-driven, it wouldn't be appointed, it could be involved in organizing talks at major meetings to garner visibility, and in nominating people for awards and prizes."

The very first organizing group for FDI began meeting in 2017, co-lead by Simmons and Elena Long, Assistant Professor of Physics at the University of New Hampshire; in early 2019, FDI's organizing committee drafted their proposal and petition for formation, as well as the by-laws that will govern the Forum's activities and initiatives. According to Simmons, this was a long process, rooted in the diverse organizing committee members getting to know one another's unique viewpoints and varied experiences while discussing sensitive issues.

"We had to be very careful in any given meeting to listen to what people were concerned about, not push the conversation...We had to be very slow and deliberative," says Simmons. "It took us a long time to go through and get the first foundational documents that come before the bylaws, the mission and the vision and the objectives and so on...The big challenge was just going slowly enough to make sure we were considering all the tricky questions. The mechanics of writing bylaws is manageable if you really, really know what you want to say. But we had to work very hard to know what we wanted to say."

Throughout the process of organizing FDI, the committee worked closely with Brown and Plisch on the APS staff, who offered assistance and additional perspective from their own work in diversity and inclusion programs for APS.

"APS is on a path to really significantly impacting the physics community in terms of diversity inclusion. I see this in the strategic plan and how diversity is a prominent feature. I see it in the support from the very top level, from [APS CEO Kate Kirby] all the way down to staff, to members of the diversity programs that we've got going," says Brown. "It was only a matter of time before [FDI] was created. And I think that now is the ideal time because we have all this momentum."

A key issue for the FDI organizing committee was addressing how to word by-laws that ensure the leadership of FDI will continue to give voices to people from varied backgrounds and minority groups within physics.

"An underlying question was how the [the by-laws] could ensure that the voices of all the different groups that need to be heard are going to be heard...really listening to what they've experienced and the issues they know are important," says Simmons. "That's what we were trying to do in the meetings and we were trying to write that into the bylaws. By its structure, the FDI would make sure all of these different voices are not just heard but listened to—that they are given weight and value. And making sure that among the leaders of the FDI there would explicitly be individuals who are charged with making sure that physicists with disabilities, LGBTQ physicists, and so on, reliably have a voice."

In addition to efforts to promote gender equity in physics, Simmons has been involved with projects to support inclusion of LGBT+ physicists since meeting Long, a nationally recognized advocate for LGBT people in science. Simmons and Long have now worked together on a variety of diversity and inclusion projects, from the lgbt+physicists OutList and the first edition of its Best Practices Guide, to the *2016 APS LGBT Climate in Physics* report.

"Both of my children identify as LGBTQ, so I was interested in seeing what I could do within our community," says Simmons. "[Long] helped me get involved with lgbt+physicists, which produced the ally list and the OutList and the Best Practices guide for department chairs. And then a few years later, Kate Kirby requested the climate report. That team of authors, which drew heavily upon the organizers of lgbt+physicists, came up with the recommendation for a forum."

Now that FDI has been approved by the APS Council, the Forum can begin work in earnest to promote diversity and inclusion on a large scale across APS. Simmons hopes to see practical ideas from APS members on ways to improve the climate in physics for everyone, such as new best practice guides, improved accessibility at APS meetings, and other coordinated efforts to promote diversity and inclusion.

"Over the longer term, I hope that the FDI can be a place where we can have tough conversations about the barriers many physicists encounter. We should name the things that worry us and try to be better colleagues to one another," says Simmons.

NOBEL PRIZES

The Nobel Lectures in Physics and Chemistry: The View from Stockholm

BY ABIGAIL DOVE

On a cold December day in Stockholm, Sweden, the 2019 Nobel laureates in Physics and Chemistry—among them three APS members—delivered their Nobel Lectures.

The Nobel Lectures are a proud tradition that light up Stockholm's dark winters. The lectures punctuate the days leading up to the Nobel Prize Award Ceremony on December 10, the anniversary of the death of Swedish scientist Alfred Nobel, who established the Prize in his will. Most Nobel Lectures are free and open to the public, so as both a scientist and an eager new Stockholmer six months into my studies at the Karolinska Institute, I was determined to attend.

I quickly learned that this is easier said than done. Lining up early enough to secure one of the 1,200 available seats at Stockholm's grand Aula Magna auditorium is something of an endurance sport in the harsh Swedish winter. I arrived nearly two hours before the doors opened for the back-to-back lectures for the Physics and Chemistry prizes.

The 2019 Nobel Prizes in Physics and Chemistry exemplify the diversity of achievements encompassed in Alfred Nobel's somewhat enigmatic definition for prize-winning work: discoveries that have "conferred the greatest benefit to humankind." The 2019 Nobel Prize in Physics (see *APS News* November 2019) was awarded for theoretical and experimental contributions to understanding the universe and our place in the cosmos, underscoring the value of pure, curiosity-driven research. On a more earthly level, the 2019 Nobel Prize in Chemistry (see *APS News* November 2019) was awarded for the development of rechargeable lithium ion batteries, which has subsequently enabled the revolution in wireless electronics and opened new frontiers for storing renewable wind and solar energy.

IMAGE: © THE NOBEL FOUNDATION
PHOTO COURTESY OF LOVISA ENGBLOM

The doors to the lecture hall mercifully opened just as an icy mix of rain and snow was beginning to fall, and there were barely any empty seats to be found when APS Fellow James Peebles (Princeton) took the stage to kick off the Nobel Lectures in Physics. Peebles is credited with developing the theoretical framework for our modern

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Vietnam's Institute of Physics (IOP). He told me that the government of Vietnam used to send many physics students to train in the Soviet Union and other socialist countries. When they came back, their main task was educating teachers, so these physicists had little time to conduct research.

However, in 1969, the Vietnamese government established the IOP—a national laboratory in the spirit of US national labs. "The quality of the research has gradually improved since then," Nguyễn Văn Hiệu said. The IOP is one of two dozen institutes in the Vietnam Academy of Science and Technology (VAST), which has a large campus in the middle of Hanoi. I paid a visit to the IOP's olive-colored building in a corner of the VAST campus and met with its director Đinh Văn Trung. He said that the Institute's $1 million budget supports 150 staff members, around a third with PhDs. Most of the IOP scientists do theoretical research, collectively publishing around 100 papers per year in national and international journals.

One of the positive signs for the IOP and other physics institutions is the government's Program of Development in the Field of Physics by 2025. This program (and a similar one for mathematics) singles out research sectors that can help accelerate the economic development of the country, said Nguyễn Văn Hiệu. With input from the physics community, the program has targeted top research priorities in theoretical and computational physics, condensed matter, quantum optics, and nuclear physics.

The program also places an emphasis on applied physics, such as materials science. Not far from IOP is the modern-looking building of the Institute of Materials Science (IMS), today the biggest institute at VAST, with 250 staff members, 23 research labs, 4 R&D centers, and 1 key laboratory that benefits from special government funding. With an annual budget of around $4 million, the institute has invested in a variety of high-tech equipment, such as electron microscopes and spectrometers and material fabrication systems, which it makes available to outside users.

I met with Trần Quốc Tiến, head of IMS's optics and spectroscopy division, who presented the strategy behind the IMS research program. "From the beginning, we tried to fill a niche that meets the demands of both international collaborators and local researchers," Trần Quốc Tiến said. He showcased some results of this strategy: basic research on quantum dots and carbon nanotubes as well as more applied investigations into renewable materials and anticorrosion strategies. He also talked about several international collaborations with laboratories in Europe and Southeast Asia as well as the US.

Collaborations with the West are a fairly new thing. After North and South Vietnam reunited in 1975, the country's physicists mostly collaborated with the Soviet Union and other Eastern European countries. However, when the Berlin Wall came down in 1989, many of these connections faded away. Since the 1990s, Vietnamese society has shifted its focus toward the West. Representative of this change is the physics faculty at Vietnam National University (formally Hanoi University), where I spent an afternoon meeting professors and students. The academic program at VNU was originally modeled after a Soviet university, explained Ngạc An Bang, dean of the faculty of physics. But in 2009, the physics program changed to a more Western-like credit-based format, taking input from the department of physics at Brown University in Rhode Island.

With 750 students, VNU has the largest physics department in Vietnam, and the only one to be ranked by *US News and World Report* (#472 in the field of physics). More than half of its faculty was trained in North America, Europe, Japan, or South Korea. "Luckily we have the chance to study in the West," Ngạc An Bang said. The main research areas are theoretical physics, solid-state physics, materials science, nuclear physics, and particle physics.

The opportunities for graduates with a physics degree are still rather limited within Vietnam, admitted Đinh Văn Trung. "Many graduates end up going abroad," he said. However, new developments in Vietnam may help to keep more students at home. In the past few years, several private universities have opened up, often with direct support from industry. Compared to public institutions, the pay for professors can be considerably higher at these private schools.

There are also new funding opportunities meant to boost home-grown research. The National Foundation for Science and Technology Development (NAFOSTED), similar to the National Science Foundation (NSF) of the US, "has been providing valuable financial support to Vietnamese scientists in multiple disciplines," said Phan Mạnh Hưởng, who studied at VNU but is now a researcher at the University of South Florida. As an example of a local scientist benefiting from this support, he cited Lê Anh Tuấn, who received NAFOSTED grants for nanomaterial research and is now director of the Nano Institute at Phenikaa University, one of the private schools in Hanoi.

With future possibilities opening up, I was curious if there was anything in Vietnam's past that might inspire more young people to choose physics. Several scientists mentioned to me the Temple of Literature in Hanoi, where the first university in Vietnam is located. That school, built in the 11th century, was open to anyone who worked hard and could pass the required tests. Touring the Temple on one of my last days in Vietnam, I was impressed by the stelae of doctors, in which stone turtles carry tablets with the names of past graduates: A reminder perhaps that the road to scholarly achievement can sometimes be slow, but the rewards can be long-lasting.

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CUWIP CONTINUED FROM PAGE 3

meet the needs of student attendees, with guidance from APS to ensure the site includes all the components of a successful conference. Allowing sites to come up with their own unique conference often results in new ideas for reaching women in physics.

"Probably my favorite site last year was New Jersey, because they did something a little different: They had a pre-CUWiP for high school students for a couple of hours," says Kai Wright, Senior Coordinator at APS. "Most high school students have an interest in physics, and some of them don't have access to a physics department. This was just a brief introduction about what physics can be like if they major in it."

Surveys are conducted across all CUWiP sites each year, and since all sites have slightly different programs, the results allow organizers to examine different tactics for creating the best possible conference. Occasionally this means working with speakers to make sure students receive the right messages about how to succeed in physics, but one of the largest changes to CUWiP as a result of these surveys is the creation of dedicated networking time at all CUWiP sites.

"Our evaluators have stressed the importance of networking time. When you organize a big conference, it's easy to think 'I want them to hear this talk,' but you grow your community connections by having lunch breaks and coffee breaks and workshops where you can talk to other people," says Goertzen. "It's really important that [students] walk out of here knowing more people."

Through networking and other events, the ultimate goals of CUWiP are to give undergraduate women in physics the opportunity to experience a professional conference, learn information on graduate schools and professions in physics, and gain access to a community of women in physics. The purpose of CUWiP, Goertzen emphasized, isn't necessarily to promote advanced degrees in physics.

"The goal of CUWiP is to get students to complete their undergraduate degree and go on to postgraduate options that are physics related. That could be a PhD or a master's, but it could also be working in R&D or working in a lab, or high school teaching," says Goertzen. "I want [undergraduate women in physics] to graduate with a degree and to think they can use physics in their future and to know that there are many options."

CUWiP also strives to build community among women in physics, especially for those who come from smaller physics departments without a strong network of mentors or role models.

"Smaller schools and departments may only have one to two female students in physics, and they may not feel like they're included [in the physics community]. CUWiP shows them that there are more than just these two people in your department," says Wright. "CUWiP shows students that they're not alone in the undergraduate community."

METHANE CONTINUED FROM PAGE 4

do for the planet. Methane is the primary component of natural gas. It has a shorter lifetime in the atmosphere than carbon dioxide (CO_2), but it has higher global warming potential. So, we must strive to prevent it from escaping into the air.

"Second, we need to protect natural gas' license to operate. When used in electricity generation, natural gas has less than half the CO_2 emissions of coal, and it also can be a vital backup to renewables. But to maximize the climate benefits of gas—and meet the dual challenge of producing more energy with fewer emissions—we need to address its Achilles' heel and eliminate methane emissions.

"Third, there is a clear business case for doing this. Simply, the more gas we keep in our pipes and equipment, the more we can provide to the market."

The APS Office of Government Affairs is committed to doing its part to ensure the rollback doesn't happen, including organizing meetings for APS members to discuss the issue with congressional staffers on Capitol Hill. APS staffers in the Ridge, NY office recently traveled to Capitol Hill and met with staffers representing their congressional delegation on the issue.

"We want APS members to know that we hear their concerns about this very important issue, and we're responding," said APS Chief Government Affairs Officer Francis Slakey.

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PLAN CONTINUED FROM PAGE 1

educational events on ethics matters at APS meetings.

Diversity, Equity, and Inclusion: In addition to new initiatives such as the APS-IDEA project, APS is establishing a Diversity, Equity, and Inclusion Task Force to explore ways to improve the participation of women and underrepresented minorities in the physics community and the Society. Most recently, a new membership unit—the APS Forum on Diversity and Inclusion—has been approved by the APS Council following a strong petition by APS members (see page 1). Associated with these efforts, APS has joined the Societies Consortium on Sexual Harassment in STEMM (science, technology, engineering, mathematics, and medicine) to share knowledge and expertise in combating sexual harassment in the sciences (see *APS News*, July 2019).

Industrial Physics Task Force: Since 2013, APS has supported an Industrial Physics Fellow (see *APS News*, December 2013) who is tasked with engaging members in the private sector and informing students about career opportunities in industry. A task force is being constituted to review and bolster APS efforts to best serve and attract industrial physicists. As one of the next steps, APS is changing the position of Fellow to that of Director of Industrial Engagement to further enhance the connection between the Society and both members and non-members in industry.

Member Attraction and Retention Study: In December, the APS Committee on Membership and the APS Membership Department convened a study group to evaluate member and non-member perceptions of APS. With the help of consultants, the group will analyze existing member data and also launch a survey to understand what programs, benefits, and services are most needed, as well as to identify new or underserved segments of the physics community. The group expects to have actionable results by mid-2020.

Science Mobility Initiative: There has been a precipitous drop in applications to US universities from students abroad, and a recent APS survey reveals significant challenges faced by students seeking visas to study in the US (*APS News*, December 2019). Among the actions APS has taken are: advocating for the Keep STEM Talent Act in Congress to allow students to study in the US and then permit them to seek work in the US; supporting Congressional staff in drafting a resolution that clarifies the essential contribution of international students and scientists; and engaging vigorously in discussions with policymakers to help ensure a healthy balance between security concerns and openness. For more, see the Back Page article "Openness, Security, and APS Activities to Help Maintain the Balance" by the 2019 APS Presidential Line in the August/September 2019 issue of *APS News*.

New Annual Leadership Meeting: Each year at the end of January, APS has held a Leadership Convocation to bring together the leaders of APS membership units, the Board of Directors, and APS staff to share knowledge about the Society. Starting in 2020, this gathering will be expanded to an Annual Leadership Meeting to strengthen the presence of APS in policy, scientific, and public arenas. This will be an opportunity to bring attention to forefront physics and science policy issues and convene policymakers, international physics leaders, and student ambassadors to discuss international cooperation, collaboration, and competition.

Launch of *Physical Review Research*: To offer more options for authors and readers of research results, APS launched its fourth fully open-access journal, *Physical Review Research*, with the first papers published in August 2019 (see *APS News*, August 2019). The journal is positioned alongside *Physical Review A–E*, with similar selection criteria to these established titles. *Physical Review Research* welcomes papers from the full spectrum of research topics of interest to the physics community. By mid-November, *Physical Review Research* had published its 200th article, well ahead of expectations.

March Meeting Task Force: In recent years, the APS March Meeting has grown annually by about 10 percent in attendance. While a strong measure of success, this growth presents challenges. A new APS task force has been created to explore ways to build upon this success while adapting to the changing physics landscape and, in particular, strengthening the meeting's relevance to students and those in the private sector. The group is chaired by Sharon Glotzer (University of Michigan) and Barbara Jones (IBM). Among other activities, the task force will hold a Town Hall session at the upcoming APS March Meeting in Denver.

For more information on the APS Strategic Plan: 2019 *visit go.aps.org/strategicplan.*

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understanding of how the universe evolved after the Big Bang. His lecture provided a journey through cosmology, including the cosmic microwave background radiation from the Big Bang, the existence of dark matter and dark energy comprising a large part of the cosmos, and the structure of the universe as a "cosmic web" of galaxies. He emphasized that "on occasion we're driven by the brutal weight of the evidence," but nature occasionally operates by rules we can discover "by pure thought, which can be remarkably effective."

The other half of this year's physics prize was jointly awarded to University of Geneva's Michel Mayor and Didier Queloz, who in 1995 made the first discovery of a planet outside our solar system, the Jupiter-sized 51 Pegasi b, located about 50 lightyears from Earth. Mayor emphasized that the discovery of this planet brought with it the implication that many of the hundreds of billions of stars in the Milky Way should have planets as well, adding new weight to age-old philosophical questions about our place in the universe. Queloz explained that there are now over four thousand known planets, most of which look nothing like our own. This has focused attention on the physical processes by which planets form and evolve.

The Nobel Lectures in Chemistry proved just as stimulating, highlighting how discoveries from this year's three laureates—APS Life Member M. Stanley Wittingham (SUNY Binghamton), APS Fellow John Goodenough (University of Texas at Austin), and Akira Yoshino (Asahi Kasei Corporation; Meijo University)—culminated in the development of the lithium ion battery.

Wittingham is credited with the development of the first functional lithium battery. Reflecting on now-ubiquitous battery technology born from this early work, Wittingham remarked that he is "not even close to being done." Modern lithium ion batteries deliver less than 25 percent of the theoretical energy density they contain, leaving plenty of room for further research and improvement.

Goodenough subsequently doubled the lithium battery's energy capacity by building the cathode using a metal oxide instead of Wittingham's metal sulfide. This also enabled the batteries to be manufactured in an uncharged state and charged afterwards, a decisive step toward the mobile, wireless technology we use today. At an impressive 97 years of age, Goodenough is the oldest laureate in the history of the Nobel Prize. Looking back on his career of over 70 years, he remarked on how fundamental curiosity-based research can evolve into major applications for society.

Finally, Yoshino's lecture focused on his work refining the lithium battery's anode. He found that Goodenough's lithium cobalt oxide cathode functioned well with a carbon-based petroleum coke anode, and this system could be based entirely on lithium ions—a safer, less-flammable alternative to pure metallic lithium. This was the final step in making the batteries suitable for widespread commercial use. Noting that most of today's lithium batteries are used for mobile information technology, he was hopeful for greater utilization of these for greener means of transportation.

To this end, the urgency of mitigating climate change emerged as a common thread. To complement the chemistry laureates' focus on cleaner energy and ending our dependence on fossil fuels, Mayor pointed out—to a stirring round of applause—that despite the existence of other planets in the Milky Way, the closest one would take over 10 million years for humans to reach if travelling at the velocity of Apollo 11, leaving "no Plan B" for us on Earth if environmental destruction continues.

Each laureate also emphasized their appreciation for the scientists who came before them and who worked alongside them, drawing a sustained standing ovation. The occasion was as inspiring as it gets, not least of all because the experience was shared by a community of people—from high school students to retirees, from all corners of the globe—who waited in the cold to witness it.

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JUPITER CONTINUED FROM PAGE 2

vortex below. Using high resolution imaging and computer analysis, Marcus and his team were able to measure what's happening to the vortex underneath the cloud layer.

"We determined the actual boundary of the underlying vortex, which is the machine that drives the red spot, and it's not completely correlated with the clouds," said Marcus in a press conference. "It's not at all clear that the shrinking of one has to do with the shrinking of the other: you can't just conclude that if the cloud is getting smaller that the underlying vortex is getting smaller."

The mismatch of clouds and vortex is possibly what started the worry about the Great Red Spot in the first place: the small vortices that interacted with the red spot don't always have their own clouds, allowing them to attract less attention from astronomers as they move across the planet, until they moved too close to the Great Red Spot. The spot is a high-pressure system that turns in the opposite direction of the planet, making it an anti-cyclone. Jupiter has other storms that are also anti-cyclones, but low-pressure cyclones that turn in the direction of the planet also exist—they just don't reliably produce clouds announcing their presence. The existence of invisible non-cloud producing cyclones can be inferred when they come close to an anti-cyclone, causing the visible anti-cyclone to act differently.

According to Marcus, the observation of the Great Red Spot flaking was simply a result of the strong anti-cyclone interacting with both a smaller anti-cyclone and a cyclone.

"There are two phenomena that I believe led to the observation last spring of these flaking events, and one of them is mergers," said Marcus. "Anti-cyclones attract each other, while anti-cyclones and cyclones repel each other. It's like the opposite of electric charges."

When two anti-cyclones interact, the smaller of the two will be absorbed by the other, but the merger isn't instantaneous: a visible bulge in the boundary of the anti-cyclone's clouds can be seen until it is fully absorbed. In the case of anti-cyclones and cyclones, as the outer boundaries of their vortices interact, it creates what's called a stagnation point. Typically this causes an anti-cyclone to be observed as slightly altering its East-West path across Jupiter by moving slightly up or down longitudinally as it avoids the stagnation point.

When the Great Red Spot simultaneously encountered an anti-cyclone (which it tried to merge with) and a cyclone (which created a stagnation point) the undigested anti-cyclone was thrown off by the stagnation point, creating the blades or flakes observed by astronomers.

"Many mergers occur, it's a perfectly normal thing: They were first seen by Voyager in 1979, and they've been seen very frequently after that. When the red spot digests other clouds associated with the other anti-cyclones, the clouds don't immediately get digested," said Marcus. "We know for sure that, about every 10 years, a cyclone meets a visible anti-cyclone. They get these stagnation points. When we have two of them together, which happened last spring, it produces these blades. Both of these are very normal healthy activities for a red spot and its colleagues, so we do not believe at Berkeley that the red spot is dying."

PARTNERING CONTINUED FROM PAGE 1

to advocate for increased federal funding for science. For instance, APS member Dany Waller, a student at the University of Kentucky, wrote a piece in the *Courier-Journal* newspaper, urging US Senator Mitch McConnell to work with his colleagues to raise the budgetary caps impacting funding for key science agencies. Additionally, other APS members sent letters and participated in meetings to advocate for the funding increases. The result: Deep cuts to the science budget that were proposed by the Trump Administration were reversed by Congress. The Department of Energy's Office of Science received a 5 percent increase for fiscal year 2019, bringing its total budget to \$6.59 billion, according to a budget summary compiled by the American Institute of Physics. The National Science Foundation's budget jumped 4 percent, resulting in a total budget of \$8.1 billion. And the National Institute of Standards and Technology's Scientific and Technical Research and Services account—which supports NIST laboratories, user facilities and grant programs—remained steady at \$725 million.

Visas & Immigration: Alerted by Society members, APS OGA partnered with physics department chairs to address concerns about declining enrollment in graduate physics programs. A follow-up survey indicated a significant drop in international applications to physics PhD programs across the country and provided a policy roadmap for reversing the decline. Another survey, carried out by the Society in conjunction with the Forum on Graduate Student Affairs (FGSA) and the Forum for Early Career Scientists, examined the challenges international students are experiencing while their visas to study in the United States are processed. To address these issues, APS OGA, with guidance from APS's Physics Policy Committee, is leading efforts to garner support for two key policy proposals: (1) making the F-1 visa "dual intent" and (2) providing a path to a green card for students who earn advanced STEM degrees from US institutions and secure job offers from US employers. APS OGA worked with both the Senate and the House to have legislation introduced—the "Keep STEM Talent Act"—that implements both APS policy proposals. APS's government affairs team worked with APS members to write op-eds and participate in in-state and DC meetings with staffers representing members of Congress. Teams of APS members in Iowa, North Carolina, and Utah met with congressional staffers to highlight the issue. APS member Amber Lauer, who participated in a meeting with US Senator Thom Tillis's office and who is a postdoctoral research associate at Duke University, wrote an op-ed in the *Raleigh News & Observer*, urging Tillis to co-sponsor the Keep STEM Talent Act. APS member Noah Finkelstein did his part in the effort by writing a piece for the *Colorado Springs Gazette*, asking US Senator Cory Gardner to support legislation that would "make the F-1 student visa 'dual intent' and provide a path to citizenship for international STEM graduate students."

Combating Sexual Harassment in STEM: Within seven months, the Combating Sexual Harassment in Science Act of 2019 went from being introduced in the House—timed with the APS Congressional Visits Day in January—to passing the full chamber in July. FGSA and APS OGA contributed to the outcome by partnering with APS members across the country to contact congressional representatives about the legislation. "The passage of the House bill is a success on a path that requires continued attention and measures to reach a level of zero percent of individuals being harassed," said FGSA Chair Tiffany Nichols, a PhD student at Harvard University. APS members also held local meetings on this issue in several key states, most notably with the staff of US Senator Lamar Alexander, chair of the Senate Health, Education, Labor & Pensions Committee, which now has jurisdiction over the bill.

Climate Change: Climate change continued to be a top concern among six key issues voted on by APS members during the March, April, and DAMOP Meetings. In response to members' concerns, APS submitted a public comment opposing the EPA's proposed policy amendments to curtail regulation of greenhouse gas emissions (see p. 4). APS urged the EPA to instead carry out a rigorous assessment of methane emissions—a major contributor to climate change. Recent scientific results indicate that the negative environmental impact of methane is significantly higher than previously estimated. APS members were encouraged to submit their own comments on the proposed amendments before the EPA November 25 deadline. This will be a substantial advocacy issue for APS throughout 2020.

Helium: APS continued to advocate for solutions to the helium issues academics are facing by working with APS members on a key op-ed in *The New York Times* and through in-state and DC office visits with staffers representing members of Congress. APS member Joseph DiVerdi, a chemistry professor at Colorado State University, authored the piece in the *Times*, underscoring two crucial recommendations in APS's helium report. He wrote: "Congress should enact legislation that keeps the federal reserve past 2021, while serving only projects funded by the federal government (after all, the reserve is paid for with tax dollars). It should create an extensive helium recycling program modeled on the modest and successful program run by the National Science Foundation." In addition, APS has formed teams across the country, including in Arizona, Indiana, and Colorado, to advocate in their local offices on this important issue. In a related item, APS member Sophia Hayes, a chemistry professor at the University of Washington in St. Louis and a member of the APS-ACS-MRS Liquid Helium Report Committee, highlighted the need to enact APS's proposed helium policies by serving as a witness during a critical minerals hearing sponsored the House Science Committee.

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FLU CONTINUED FROM PAGE 3

term exposure and close proximity to a disease's source. To see how emitted aerosols might travel, Asadi employed a transient eddy model, which more accurately captures dispersion in indoor environments.

"[Wells-Riley] assumes that the concentration of expiratory droplets, or the virus that is being released into the air, is not a function of time or location. So you assume that the concentration of the virus is the same here versus 10 meters away," she said. "In our model, we are going to consider the concentration as a function of time and also location: We expect to have higher concentrations close to the source of infection versus away."

Higher concentration of droplets will typically translate to a higher pathogen load, and thus a higher probability of contracting an infection. In her talk, Asadi shared a sample probability created from the transient eddy diffusion model: Assuming a source is in the center of a four meter by four meter room and speaking for 60 minutes, people one meter away from the speaker have a ten percent probability of contracting the disease.

Using data from different expiratory activities like breathing or speaking at different volumes, Asadi's model shows breathing presents the lowest probability of disease transmission, with speaking loudly and coughing carrying the same probability. But since talking can happen continuously, "it can be even more dangerous than coughing," said Asadi.

This model for probability of disease transmission can be modified to fit a myriad of situations and groups of people performing a variety of expiratory activities, provided they're in an indoor space.

"It's just a matter of the correct parameters that we use. The data that we currently have for particle emission rate is for people from 18 to 45, but if we have data available for children we can definitely apply it in our model," said Asadi. "We can consider other cases—there can be more than one person if you are in a bigger environment or in a hospital—we can cover all of this."

So, during this flu season, in addition to washing your hands regularly, you might do you yourself and your colleagues a favor—talk softly and carry a big box of tissues.

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Integrative Design for Radical Energy Efficiency

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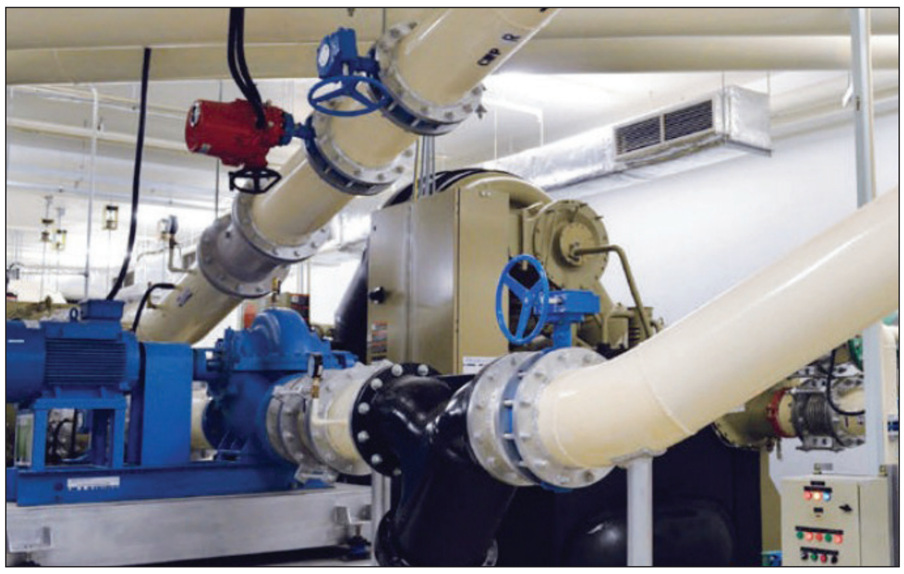
*Note: This article is adapted and excerpted from an invited talk by the author at the APS April Meeting in Denver in 2019 in a session organized by the APS Forum on Physics and Society (*APS News, *October 2019). The full presentation, with the slides to which the remarks refer, can be viewed at go.aps.org/2En5Hmb.*



Better pipe and pump design (eg, use large pipes with gentle curves and small pumps, rather than sharply bent small pipes and large pumps) can reduce flow friction by 80-90%. IMAGE: ROCKY MOUNTAIN INSTITUTE

Integrative design in the author's residence in Colorado means that no combustion energy sources are needed for heating and cooling. IMAGE: ROCKY MOUNTAIN INSTITUTE

Around 1975 our government and industry all said that the energy needed to make a dollar of gross domestic product (GDP) could never drop. A year later, I heretically suggested it could drop 72 percent in 50 years [1]. So far, it's dropped 58 percent in 43 years, but just the innovations already added by 2010 can save another threefold, or twice what I originally thought, at a third of the cost. Today that looks conservative because optimizing buildings, vehicles, and factories as whole systems—not as piles of parts—can often make very large energy savings cost less than small or no savings, turning diminishing returns into increasing returns.

Depleting only stupidity

Economic geologists know that a mineral's reserves—the identified deposits profitably extractable with current technology—are only a small part of the resource base. Most energy analysts also narrowly define reserves of energy efficiency like mineral resources, but the actual energy efficiency reserves are several-fold larger than those now typically recognized and captured.

The "missing majority" is hiding in plain view and is exploitable by integrative design, as I will describe. But this geological analogy breaks down on cost: orebodies are finite assemblages of atoms, while energy efficiency resources are infinitely expandable assemblages of ideas. Exploiting ideas depletes only stupidity, a very abundant resource. All of this is documented in a peer-reviewed paper [2] called "How Big is the Energy Efficiency Resource?"

The evidence across all sectors shows that unlike oil or copper, most new energy efficiency reserves cost less because they come not from adding more or fancier widgets but from using fewer and simpler widgets—more artfully chosen, combined, and timed and sequenced.

An example—my house

I'd never built a house before, so I didn't know what was impossible. My wife Judy and I live near Aspen, Colorado, at 2200 meters elevation. Temperatures there used to dip as low as minus 44 degrees Celsius. We saw up to 39 days of continuous midwinter cloud, but our house uses no combustion. (That's so 20th century.) Instead, we use superinsulation, ventilation, heat recovery, and superwindows that insulate like 16 or even 22 sheets of glass but look like two and cost less than three, making the house 99 percent passive solar heated and 1 percent active solar.

Eliminating the heating system more than paid up front for the efficiency that displaced the heating system, slightly reducing total construction costs and then saving also 90 percent of electricity and 99 percent of the water heating. It was all paid back in 10 months with 1983 technologies, which are not nearly as good or cheap as those we have now.

Our house helped inspire more than 160,000 European passive buildings that likewise have no heating and roughly normal construction costs. An analogous approach also works fine in Bangkok; practically everyone on earth lives in a climate somewhere between Bangkok and Old Snowmass, Colorado. Integrative design gives many benefits from each expenditure. For example, the arch that holds up the middle of my house has 12 different functions, but it has only one cost.

Transportation

What about our biggest oil burner—automobiles? Well, the propulsion system or powertrain uses 4/5 of the fuel energy before it reaches the wheels, but our savings should start downstream, *at* the wheels. Here's why. Just a fifth of a modern car's fuel energy reaches the wheels and moves the car. Of that, nearly half heats the air that the car pushes aside (a loss that rises as the cube of speed). Most of the rest heats the tires and road. So only the last ~6 percent of the fuel energy accelerates the car and then heats the brakes when you stop. But 19/20 of the mass you're accelerating is the heavy steel car, not you. So just 1/20 of that 6 percent or about 0.3 percent of the fuel energy ultimately moves the driver. That's not very gratifying after one and a third centuries of devoted engineering effort.

Both acceleration and rolling resistance depend on mass, which therefore causes most of the tractive load. Reducing losses in the powertrain is harder than reducing tractive load, and it's also less rewarding, because saving one unit of energy in the powertrain saves only one unit of fuel in the tank. But saving one unit of energy at the wheels avoids four or five more units now lost in getting that energy to the wheels. So we should first reduce tractive load, then improve the powertrain, which then shrinks for the same acceleration, saving more weight, and also saving capital cost to help pay for the lightweighting. This is integrative design.

Ultralight carbon-fiber autos can save far more oil than Saudi Arabia pumps and, with simpler designs, can be made at normal cost. How do we know that? Well, because BMW did it six years ago with the carbon-fiber electric car that I drive, the i3. The i3 reportedly made money from the first unit off the assembly line. Its carbon fiber is paid for by the smaller batteries that its lightness saves, and fewer batteries also means faster recharging. Its integrative design decreases mass a lot more than normally assumed. Its manufacturing is radically frugal, eliminating conventional body and paint shops, which are the two hardest and most costly steps in making a normal car. Making the i3 needs one-third the normal capital and water, and one-half the normal energy, space, and cost.

You can keep going around the design spiral, making components smaller as their structural loads shrink, because the less weight you have, the less weight you need. Lightness begets lightness. Many big parts then disappear. A good hybrid design, for example, can eliminate transmission, clutch, flywheel, driveshaft, U-joints, axles, differentials, starter, and alternator. That's nine things, each saving even more mass and then you go around the cycle some more and take out more mass.

At first it might seem like the special materials and powertrain and design may raise your manufacturing costs, but after more mass removal, you need less carbon fiber and powertrain. The advanced composite structures can get so much simpler that these savings pay for the carbon fiber, making the ultralighting roughly free, as BMW proved.

Start downstream

My team's latest ~$40 billion dollars of industrial retrofit designs typically found about 30 to 60 percent energy savings, paying back in a few years on retrofits. And then in newbuilds, we find savings of typically 40 to 90 percent with generally lower than normal capital costs. These results come largely from rethinking industrial processes and redesigning basic elements like pump, fan, and motor systems.

For example, in both buildings and industry, better pipe and duct design can save about 80 or 90 percent of the flow friction. And if everybody did this, it could save roughly half the world's coal-fired electricity, typically paying back in less than a year in industrial retrofits and instantly in newbuilds. But this is not yet in any official study or industry forecast or climate model or government assessment, because it's not a technology; it's a design method. And most people don't yet think of design as a scaling vector—a way to make things big, fast.

And the methods are simple—it's just physics. Use big pipes and small pumps, not small pipes and big pumps. Friction drops as nearly the fifth power of diameter. Yet in practically every new building or factory, the piping is normally laid out so the flow always goes through right-angle elbows—friction. But why not lay it out so that the main flow has no bends and fewer valves? The only obstacle is force of habit. We should bend minds, not pipes.

What do such savings mean for the motors that use over half the world's electricity? From the fuel burned in the power plant to the end use, there are so many compounding losses that only a tenth of the fuel energy comes out the pipe as flow. But every unit of lower friction you save at the pipe leverages back to 10 units of fuel cost, emissions, and global warming saved at the power plant. And as you go back upstream, the components get smaller and cheaper, so the total capital cost goes down. If you know an engineering textbook that mentions this "start downstream" principle, I would love to see it.

The big picture

What can integrative design do for a big economy? Well, seven years ago our business and design synthesis, *Reinventing Fire* [3], rigorously showed how to triple US energy efficiency and quintuple renewables by 2050 needing no oil or coal or nuclear energy and at least a third less natural gas, while saving $5 trillion, growing the economy 2.6-fold, strengthening national security, and cutting fossil carbon emissions 82 to 86 percent. This needed no new inventions nor Acts of Congress, but instead, with smart city and state policies, could be led by business for profit. The first eight years of this 40-year journey are nicely on track, because the private sector smells the $5 trillion on the table.

That's exactly what should be happening. I hope these examples will encourage you to rethink why our end-use efficiency is so far from Second Law limits—and how better design, not only better technology, can help close that gap if we turn integrative design from rare to common.

The author is Cofounder and Chairman Emeritus of Rocky Mountain Institute (rmi.org).

References

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2. A. B. Lovins, "How big is the energy efficiency resource?," *Environ. Res. Lett.* **13** 090401 (2018).
3. A. B. Lovins, *Reinventing Fire* (Rocky Mountain Institute, 2014).