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APS physics

APS Panel on Public Affairs (POPA) Draft Climate Change Statement:
See Special Insert Inside

New Director of ARPA-E on Transformative Technology

On December 8, 2014, Ellen Williams was confirmed as the director of the U.S. Department of Energy's Advanced Research Projects Agency – Energy (ARPA-E). She received her Ph.D. in chemistry from the California Institute of Technology, and previously served as the senior advisor to the secretary of energy and as the chief scientist for BP. She is currently on a leave of absence from the University of Maryland, where she is a distinguished university professor in the Department of Physics. Alaina G. Levine interviewed Ellen Williams for *APS News* to discuss goals for her new job and what lies ahead. The full version of this edited interview is online.

AGL: I'd like to ask you about your physics background and why you chose physics in the first place. How has physics helped you in your career?

EW: To a certain extent, I would say that I didn't actually choose physics, I think physics chose me. I don't have a degree in physics. My undergraduate and graduate degrees are in chemistry. When I was in graduate school, I was very interested in some problems in physics, so when I graduated, I took a position in a physics department. The physical chemistry discipline and the physics discipline aren't so different that that's impossible to do, but it's not that easy either. But physics is a great background. The rigor and the discipline of physics and the skepticism that you have to bring to your discipline have been incredibly important to me all throughout my career.

AGL: It's interesting that your background is chemistry but you identify yourself as a physicist. So far in your career, what have been your proudest


Ellen Williams

accomplishments, those that you're most excited about?

EW: A big accomplishment for me was pulling together an interdisciplinary team to form the Materials Research Center at the University of Maryland. That was both an accomplishment, and very much represents a way of doing science and a way of thinking about research that I think is crucial for

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Breeding a Better Robot

By Shannon Palus

APS March Meeting 2015 — Today, true artificial intelligence proliferates only in fiction. At the APS March Meeting 2015, robotics researchers debated how we'll achieve smart robots in real life — and what we'll do with them when we get them.

There are robots that can vacuum floors, robots that beat world-class talent at chess and Jeopardy, and even robots that are capable of driving a car. These are examples of what Michigan State University computational biologist Chris Adami calls "special-purpose intelligence": robots that do just one complicated thing well, but not much more. Case in point: You wouldn't want a Roomba behind the wheel.

Currently, computers have trouble recognizing faces and learning spoken languages, both skills that infant humans quickly acquire. Babies learn by exploring their world: as they wave their arms and legs around, they receive feedback as they find some movements more pleasurable than others. They take in that sensory information through one set of neurons and link it via synapses with different neurons that control motor actions.

Artificial neural networks that work in a similar way have been around for decades, with varying results. But a new piece of hardware, presented by Seyoung Kim of the IBM T. J. Watson Research Center, would make artificial neural networks smaller and more efficient than past versions, which have required multiple digital gates and control circuits to mimic synapses.

The IBM device is a semiconductor with two electrodes sandwiching a metal oxide. Put-

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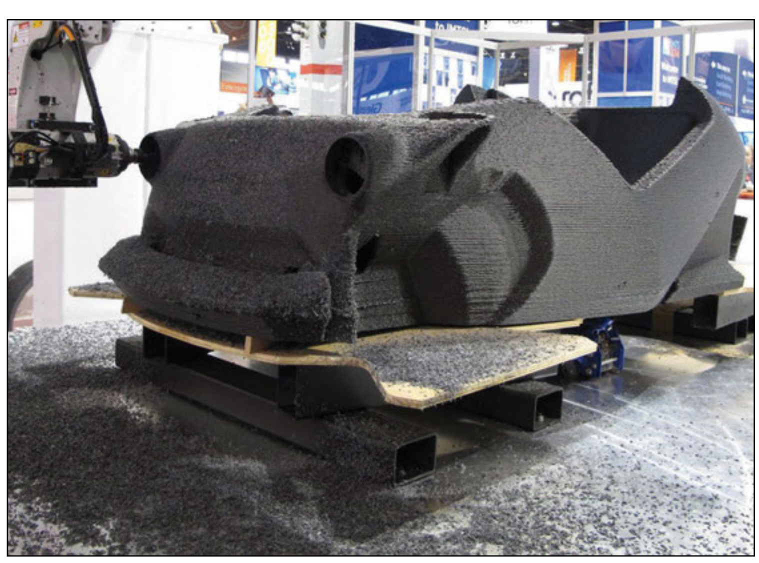
Manufacturing Revolution May Mean Trouble for National Security

By Michael Lucibella


DOE/Local Motors

The world's first 3D-printed car is an example of the dramatic changes in manufacturing.

APS March Meeting 2015, San Antonio — Additive manufacturing, more popularly known as 3D printing, could be the future of industrial manufacturing while possibly undercutting national security, experts said at the APS March Meeting 2015. This technology was the central focus of several of the industrial physics sessions, highlighting both its commercial promise as well as its policy implications. "The early promise of the technology has been demonstrated," said Prabhjot Singh, manager of General Electric's Additive Manufacturing Lab.

But the same aspects that make the technology enticing for industry — its flexibility, low cost, minimal waste, and small footprint — make it potentially dangerous for global security. The streamlined manufacturing processes that can print a car's exhaust manifold can just as easily be used to surreptitiously manufacture weapons, researchers warn.

"This is an emergent, latent, and disruptive technology for issues related to national security," said Bruce Goodwin, associate director at large for national security policy and research at Lawrence Livermore National Laboratory. "All by itself, additive manufacturing changes everything, including defense matters."

Additive manufacturing is a general term for a range of technologies that stack thin layers to produce an object. Though there are a variety of methods, generally a nozzle scans a surface, following instructions in a 3D "build" file, and squirts out a micron-thick filament as it builds up the object. Plastics were some of the first materials available, but recent developments opened up the process to a range of metals and ceramics as well.

In contrast, traditional subtractive manufacturing uses computer-controlled machines to carve a part out of a raw form. By working from the ground up, additive manufacturing can build solid shapes that were impossible with older manufacturing methods, while almost totally eliminating waste.

Though originally promoted as a means for rapidly prototyping products, 3D-printers are now producing the products themselves. Enterprises both large and small are now directly marketing 3D-printed products to consumers.

One of the fastest growing markets is fulfilling orders for obscure parts that would have been uneconomical to mass-produce using traditional machining. "[The] worldwide prototyping market is limited, but the important thing is manufacturing," said Michael Cima of MIT. "The entire system was commercialized because there was a quick way to make a few key parts."

With some improvement, the largely-automated technology promises to shrink the footprint of manufacturing. Entire machine shops staffed by a multitude of specialists could be reduced to a couple of machines overseen by a few technicians. General Elec-

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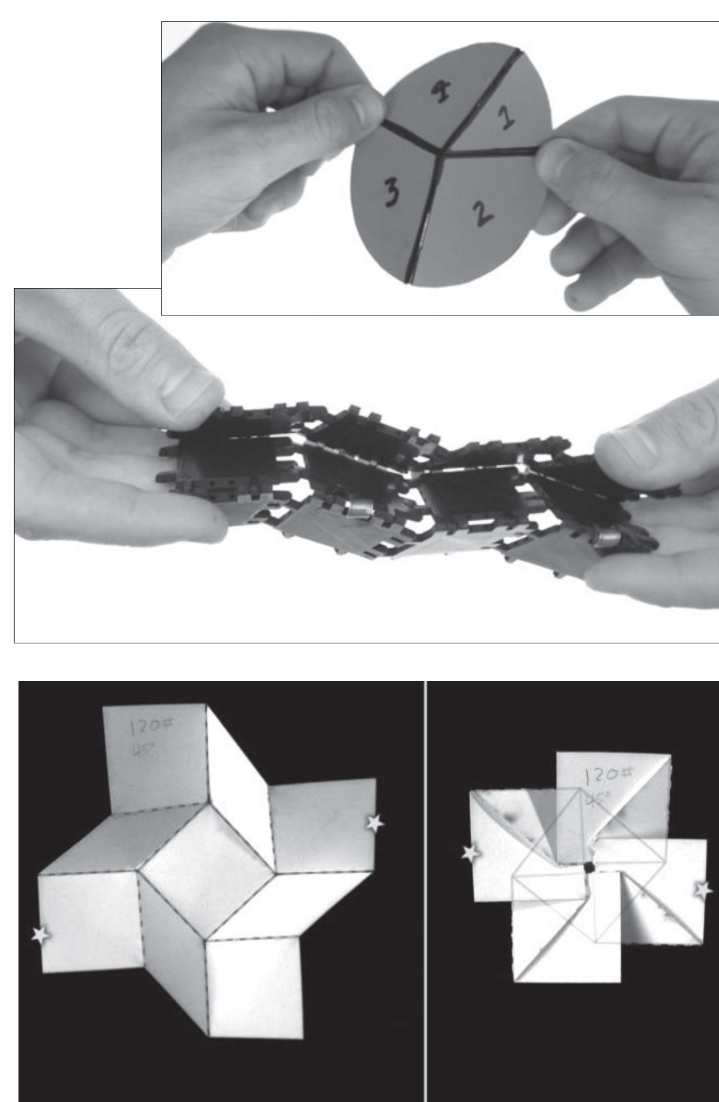
APS March Meeting: Know When to Fold 'em


Scott Waitukaitis/Leiden University

tai Cohen Group/Cornell University

At the APS March Meeting 2015 researchers showed how origami can inspire new devices. A group at Leiden University reported that 2D panels joined along fold lines (top) can pop in and out of stable 3D configurations. A similar toggle effect was seen with joined tiles (middle). A team at Cornell and the University of Massachusetts, Amherst, used a square-twist pattern to create structural toggle switches in paper (bottom) and in microscopic gel sheets that are actuated by temperature changes.

Members in the Media

"We are a story, each of us. And a story with no listener is the same as silence, as oblivion. Some stories are harder to listen to, or can't be listened to in ordinary ways, and so take a very special kind of listener. We are blessed to have Oliver as a listener, at once scribe and bard of the human condition."
Marcelo Gleiser, *Dartmouth College, on famed neurologist and author Oliver Sacks,* NPR.org, *February 25, 2015.*

"When you think about your cup of coffee, you can see that the motion can get pretty violent... . Imagine the same thing but at a much larger scale … you're going to generate forces against the walls of the container that are going to be really high every time the ship hits a wave. So the motion of the liquid inside the ship can lead to structural damage, and it can also disturb the motion of the ship itself."
Emilie Dressaire, *New York University Polytechnic School of Engineering, on understanding the fluid dynamics of coffee,* Los Angeles Times, *February 24, 2015.*

"The fact is that Spock was a cool geek… . Scientists are not always portrayed as being very strong. Usually, they're the guy with the tape on their glasses and their pants too high. He was clearly a person who had desirable components beyond just being smart."
Don Lincoln, *Fermilab, on the passing of Leonard Nimoy, who played the character Mr. Spock on Star Trek,* The New York Times, *February 27, 2015.*

"What I find interesting about this is you're suddenly talking about your work in a way you've never talked about it before."
Alan Alda, *Stony Brook University, on scientists using improv comedy classes to learn how to better communicate their research,* The New York Times, *March 2, 2015.*

"A goshawk kills by grabbing the prey and kneading its talons into it... . It needs time."
Suzanne Amador Kane, *Haverford College, who studies the flight dynamics of predatory birds,* The New York Times, *March 2, 2015.*

"We have for the first time in the long history of quantum computing an actual device, where we can test all of our ideas about error detection."
Rami Barends, *University of California, Santa Barbara, on his recent advancement in quantum computing,* The New York Times, *March 4, 2015.*

"It is a bit off, but not insanely so."
David Kaplan, *Johns Hopkins University, on an equation in a 1998 episode of "The Simpsons" that appears to predict the Higgs boson's mass,* Los Angeles Times, *March 5, 2015.*

"This plan enables us to maintain this essential quality of the Institute, which provides an interactive and stimulating intellectual environment."
Robbert Dijkgraaf, *Institute for Advanced Study, on a proposed expansion for the Institute opposed by conservationists,* The Chicago Tribune, *March 7, 2015.*

"It's just not a business where you should ever be confident."
Roger Johnston, *Argonne National Laboratory, on the security of nuclear sites in South Africa,* The Washington Post, *March 14, 2015.*

"It was a stretch for many people here."
Shirley Ann Jackson, *Rensselaer Polytechnic Institute, on establishing a series of performances at her university that marries science and art,* The New York Times, *March 15, 2015.*

"I am amazed at the movement … . AI has changed life in ways as dramatic as the Industrial Revolution."
Stephen Wolfram, *Wolfram Research Inc., on anti-robot protestors at Austin's South by Southwest festival,* USA Today, *March 15, 2015.*

This Month in Physics History

April 28, 1926: Schroedinger Describes "Wave Mechanics" in Letter to Einstein

Sir Isaac Newton ushered in a new era in physics when he devised his universal law of gravity and equations of motion. Three hundred years after Newton's death, Erwin Schroedinger made a similar contribution with an equation that is the quantum equivalent to the classical laws of motion and conservation of energy in classical physics.

Schroedinger was the only child of Rudolf Schroedinger, the owner of a prosperous oilcloth factory, whose financial independence enabled him to pursue scientific interests in chemistry and botany. Other than a part-time tutor, young Erwin received much of his early education from his father, before matriculating at an academic gymnasium in Vienna (the equivalent of a prep school in the U.S.). He loved math and physics but also appreciated German poetry and the theater, although literary criticism and rote memorization of historical facts bored him. He continued his studies at the University of Vienna, where he first attended lectures in theoretical physics by Friedrich Hasenöhrl, who became his thesis advisor.


wikimedia commons

Erwin Schroedinger

After earning his doctorate in 1910, Schroedinger worked in a laboratory for Franz Exner in Vienna, supervising the large lab courses and gaining what he considered to be invaluable experimental skills in the process. He served in World War I, keeping up with physics in the remote areas where he was stationed on the Italian front. He moved around a great deal for much of his early career, partly because of the political turmoil. By 1921, he was at the University of Zurich until he replaced Max Planck as a professor at the Friedrich Wilhelm University in Berlin six years later.

Quantum mechanics was still in its infancy, but developing rapidly. In November 1924, Louis de Broglie defended his doctoral dissertation, postulating that not just light, but matter, evinced particle-wave duality. Schroedinger heard of the breakthrough while reading one of Einstein's papers (Einstein learned of it from Paul Langevin), and was intrigued by the concept of these so-called de Broglie waves.

Schroedinger had never much cared for Bohr's model of the atom, and a footnote in Einstein's paper inspired him to model the motion of an electron around a nucleus as a wave rather than an orbiting particle. By late 1925, Schroedinger was stymied in his attempt, and decided to spend some time in seclusion at a mountain cabin in Arosa, Switzerland, accompanied by one of his mistresses. Romantic seclusion did the trick: He cracked the problem in January 1926, and then he published his wave equation for a hydrogen-like atom and also a series of four papers that year applying his equation to various other systems.

Buoyed by his breakthrough, he wrote to Einstein on April 28, 1926: "This whole conception falls entirely within the framework of 'wave mechanics'; it is simply the mechanics of waves applied to the gas instead of to the atom or the oscillator." Einstein responded with much enthusiasm. He was not alone: Schroedinger's wave equation is considered one of the most important physics breakthroughs of the 20th century, complementing rather than contradicting the matrix model developed by Werner Heisenberg around the same time. (Schroedinger's approach was easier to adopt, in fact, because it was familiar to most physicists.)

That said, he never fully reconciled his work on quantum mechanics with its philosophical implications, which he found deeply unsatisfying. The Schroedinger equation expresses the wave function of a quantum system and how it changes dynamically over time, but it doesn't define what a wave function actually is. The equation is not strictly deterministic; it predicts a probabilistic distribution of likely outcomes. "I don't like it and I'm sorry I ever had anything to do with it," he once famously observed of the traditional Copenhagen interpretation.

Despite this success, Schroedinger struggled to find a stable long-term academic position. By 1931 he was in Berlin, although that position did not last long. The Nazis rose to power in Germany in 1933, and like many scholars of that era, Schroedinger was deeply disturbed by the purging of Jewish intellectuals from the universities. He opted to leave Germany for Oxford University in England. Within a week of his arrival, he learned he had won the 1933 Nobel Prize in physics, along with Paul Dirac, who devised his own equation to incorporate electron spin, a largely new concept at the time.

It should have heralded a long-overdue period of professional stability, but rumors soon spread about Schroedinger's unconventional domestic situation: an open marriage with wife, Anny, and a son by his mistress, the wife of another colleague who had also come to Oxford at Schroedinger's insistence. Not even the luster of the Nobel Prize could save him from social censure and eventual dismissal. Princeton University made him an offer, which Schroedinger declined, perhaps because there were similar reservations about his desire to bring both wife and mistress to the U.S. Fortunately, his physics research didn't seem to suffer from all the professional upheaval: He came up with his famous paradoxical thought experiment, Schroedinger's cat, during this period.

Visa delays prevented him from accepting a position at the University of Edinburgh, so Schroedinger returned to the University of Graz in Austria, which proved to be ill-advised and badly timed. The Nazis annexed Austria within two years, and he found

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Editor . . . . **David Voss**
Staff Science Writer . . . . **Michael Lucibella**
Art Director and Special Publications Manager . . . . **Kerry G. Johnson**
Design and Production . . . . **Nancy Bennett-Karasik**
Proofreader . . . . **Edward Lee**

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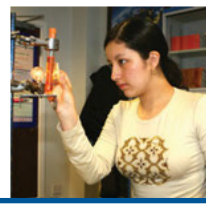
Education Corner



APS educational programs and publications

Register by May 5 for the 2015 Physics Department Chairs Conference
APS and the American Association of Physics Teachers are pleased to announce that the 2015 Physics Department Chairs Conference will be held June 5-7, 2015, at the American Center for Physics in College Park, MD. Registration opens in February. For more, see www.aps.org/programs/education/conferences/chairs/

Conference: Constructing Great Instructional Lab Experiences
The second Advanced Laboratory Physics Association conference on Laboratory Instruction Beyond the First Year of College will be held on July 22-24 at the University of Maryland in College Park, MD, and the theme is "Constructing Great Instructional Lab Experiences." The conference focuses on labs beyond the introductory sequence and features many hands-on workshops, as well as invited talks, panel discussions, breakout discussions, and poster sessions on a wide variety of laboratory instructional issues. Also, equipment vendors will provide commercial workshops. The conference immediately precedes the 2015 AAPT Summer Meeting and the Physics Education Research Conference, which will also be held in College Park. More information is at advlabs.aapt.org/conferences/2015/

APS Award for Improving Undergraduate Physics Education
Created by the APS Committee on Education, the award recognizes departments and programs that support best practices in education at the undergraduate level. Programs will be recognized for a three-year term, acknowledged on the APS website, awarded a plaque, announced in *APS News*, and recognized at the APS April Meeting. These awards are intended to acknowledge commitment to inclusive, high-quality physics education for undergraduate students, and to catalyze departments and programs to make significant improvements. Nominations for the award are being accepted until July 15. See www.aps.org/programs/education/undergrad/faculty/award.cfm

APS Excellence in Physics Education Award
The award recognizes and honors a team or group of individuals (such as a collaboration), or exceptionally a single individual, who have exhibited a sustained commitment to excellence in physics education. Nominations are being accepted until July 1, 2015. Visit www.aps.org/programs/honors/awards/education.cfm for more information.

SCHROEDINGER continued from page 2

himself in professional exile once again, despite a desperate attempt to appease the Nazi regime by recanting his former opposition — an act that earned the rancor of many of his colleagues, including Einstein. Schroedinger later apologized for this lapse in principle.

The prime minister of Ireland convinced him to join the fledgling Institute for Advanced Studies in Dublin, modeled on its Princeton predecessor. Princeton had Einstein; Ireland wanted Schroedinger. All told, Schroedinger spent a fruitful 17 years in Dublin, calling that period "a very, very beautiful time. Otherwise I would have never gotten to know and learned to love this beautiful island of Ireland." In 1956, he finally returned to Austria to take up his own chair at the University of Vienna. "Austria had treated me generously in every respect," he later recalled, "and thus my academic career ended happily at the same Physics Institute where it had begun." He died on January 4, 1961, of the tuberculosis that had plagued him for much of his life.

Further Reading

1. Einstein, A. et al. *Letters on Wave Mechanics: Schroedinger-Planck-Einstein-Lorentz*. Philosophical Library, First edition, 1967.
2. Halpern, Paul. *Einstein's Dice and Schroedinger's Cat*. New York: Basic Books, 2015.
3. Schroedinger, E. (1926) "An Undulatory Theory of the Mechanics of Atoms and Molecules," *Physical Review* 28(6): 1049-1070.

Planning Africa's First Synchrotron

By Michael Lucibella

APS March Meeting 2015, San Antonio — Africa may get its first synchrotron sometime in the next ten to fifteen years, joining other nations that seek to bolster their scientific and technological development. At this year's March Meeting, experts highlighted how scientists from across Africa and around the world are working to build the first such light source on the African continent.

SESAME

The SESAME synchrotron is a model for a light source being planned for Africa.

The project is still in its early phases, but scientists from South Africa, Zimbabwe, Nigeria, and other nations have signed on. After convening an interim steering committee in August of last year, they announced that a major planning workshop will be held in November at the European Synchrotron Radiation Facility (ESRF) in Grenoble, France.

The organization for the proposed African Light Source is patterned after the international collaboration building a third-generation synchrotron in Jordan: The Synchrotron-light for Experimental Science and Applications in the Middle East (SESAME) is a collaboration among nine member states to build a third-generation accelerator facility under the auspices of UNESCO.

"The model for [the African Light Source] is really the SESAME project, which itself is modeled on CERN," said Herman Winick, professor emeritus at the SLAC National Accelerator Laboratory.

Winick was instrumental in getting SESAME off the ground, and he is now working with the newly-formed steering committee to do the same in Africa. He added that the demand for a user facility is there. South Africa recently signed on to ESRF as a member state and has been sending 40 scientists a year there for beam time.

"Africa is developing. It has major concerns in the environmental and biomedical area that can be addressed with synchrotron radiation," Winick said. "It's very relevant to have such a facility, so dedicated, motivated African scientists can work on biomedical [and] environmental problems that are of particular interest to that region."

He added also that the team was hoping to construct the finished accelerator within ten to fifteen years.

Synchrotron facilities are both a hallmark of national development and a catalyst for it. Around the world, many countries that are ramping up their science programs build such machines to boost science and industry at home and keep their best-trained researchers from emigrating.

"That kind of scientific investment has worked for Brazil," said Antonio José Roque da Silva, director of the Laboratório Nacional de Luz Síncrotron (LNLS), the only synchrotron in Latin America. That nation opened the LNLS in 1997 and is currently working on a cutting edge, fourth-generation synchrotron called Sirius, which will be one of the world's best.

"The synchrotron project in Brazil was the most successful scientific … [effort] that Brazil has gotten into," da Silva said. "In about 30 years you start from nothing, no people, no technical training, and now we're … able to try to compete with a state-of-the-art machine and collaborate all over the world."

The original light source has been a big boost to the scientific infrastructure in Brazil, helping to make the state of Sao Paulo the scientific powerhouse of the continent. Three other labs, devoted to nanotechnology, microbiology and bioethanol research, have been built on the same campus as the synchrotron.

"Our major effort throughout these few years is to attract more and more users from different areas," da Silva said, adding that the brain-drain of scientists leaving the country for better facilities elsewhere in the world has slowed.

Other countries are similarly following Brazil's model. At the same time that Brazil started designing the LNLS, Taiwan and South Korea also were losing many talented young scientists to institutions abroad.

"Taiwan, Korea [and] Brazil started their discussions about national light sources in the 1980s," Winick said, referring to facilities that became operational in the 1990s. "In the time since then … they've trained hundreds of Ph.D.s locally without losing them. They've attracted dozens of mid-career people to return."

Iran and Turkey are currently designing and building their own national light sources. Even though both nations are members of the SESAME collaboration, the capabilities of the respective light sources will complement the capabilities of the Jordanian-based machine.

Since its announcement in 2010, engineers working on the Iranian Light Source Facility completed a detailed plan and built a number of prototypes for nearly every major component of the injector and storage rings. The synchrotron will be located at the Imam Khomeini Science and Technology Park in Qazvin province. The original plan was to have the facility online by 2018, but the schedule has since slipped.

The Turkish Accelerator Center announced in 2009 that it is currently working on building the first of its three planned projects. The TARLA free electron laser is slated for completion in 2016, while the second phase of the project, the planned TURKAY synchrotron, is still in the design phase.

"The community of users that need these machines is growing more rapidly than the available facilities and beamlines, so we need SESAME." Winick said. "We need an African Light Source and we need more national light sources."

National Academies Studies Institutional Influences on Ethics

By Michael Lucibella

A committee of The National Academies is preparing a report that will take a tougher stance on defining scientific misconduct, and focus on attacking the institutional environment that often leads to it.

"Misbehavior in science has typically been seen as a failing of the individual," said Brian Martinson of the HealthPartners Research Foundation. "We believe that it is not simply a failing of the individual; scientists simply don't behave in a void."

At the American Association for the Advancement of Science meeting in San Jose, California, committee members outlined how they planned to update the 1992 National Academies report, *Responsible Science — Ensuring the Integrity of the Research Process, Volume I,* which helped codify what qualifies research misconduct.

The report in part defined research misconduct as "fabrication, falsification, or plagiarism," a definition that was broadly adopted by the federal government in 2000. It also highlighted other "questionable research practices" that didn't amount to outright fraud but skirted the line of impropriety. These include authorship abuses, exploiting research assistants, misleading statistical analyses, and withholding data, all of which fall short of falsification and fabrication.

"We suggest that they be renamed 'detrimental [research practices],' that we don't equivocate on that issue, and don't suggest that by 'questionable' they might be ok," said Paul Wolpe of Emory University. "We want to take a stand and say no, let's call them 'detrimental research practices' because we don't want there to be any question about how we consider them and the damage that they do to science as an enterprise."

Committee members are hoping

ACADEMIES continued on page 7

International News
...from the APS Office of International Affairs

Ukrainian Scientists Need Our Help

George Gamota

Twenty-four years ago APS launched a major program dubbed the "Emergency Aid Program" (EAP) to help scientists from the former Soviet Union. They lost their funded programs as the Soviet Union came apart and 15 new nations came into being. EAP was especially critical: The financial support to the military-industrial establishment that scientists of the former Soviet Union had relied on disappeared.

Much has been written about the various programs that the West provided to Russian, Ukrainian, and other countries' scientists, among them the Nunn-Lugar Cooperative Threat Reduction Program (CTR), created in 1991. The purpose of the CTR Program was to secure and dismantle weapons of mass destruction and their associated infrastructure in former Soviet Union states. Alongside the CTR, and the APS assistance program mentioned above, the most important program was the International Science Fund (ISF), personally funded by financier George Soros, which dovetailed with the APS program and over a span of three years provided U.S. $100 million for research, teaching, and collaboration.

That was 25 years ago, but a new threat has arisen from Russia, affecting Ukraine's security and economy, and the lives of hundreds of scientists and their families in eastern Ukraine. It all started with protests in Ukraine against a corrupt president, Victor Yanukovych and his government. Soon the peaceful protests turned ugly and violent when the president's Special Forces "Berkut" contingent kidnapped, tortured, and killed over 100 innocent bystanders during the Kyiv 'Euro-Maidan' protests. Included in these causalities was one of our own, Yuri Verbytskyi, a noted geologist. His tortured and burned body was found near the airport in Kyiv (Kiev) on January 21, 2014.

Much has happened since last year in January, and a full-blown war against Russian-backed separatists has been raging for some months now in Ukraine's two easternmost regions, referred to as Donbas. First the "Masked Green men" (many former Berkut members) fled to Crimea, as it was unlawfully overrun and annexed by Russia, and then these forces started their war in Donbas. What started as a protest against a corrupt government developed into a full-scale war that has been fuelled by covert support of the Russian Federation, resulting in a million people being displaced and over 6,000 casualties. Additionally, it has been reported that over a thousand Russian soldiers have died in the conflict. Included in this tragedy are hundreds of scientists who often escaped the war zone with just their lives, leaving everything behind. Journalist Richard Stone has written about this dire situation in the January 2, 2015 issue of *Science*. A fragile ceasefire exists today but nothing has been resolved to bring peace and a return to normalcy.


George Gamota

As in 1992, APS is again being asked to help by its sister organization and colleagues in Ukraine. On January 12, 2015, the Ukrainian Physical Society (UPS) president, Maksym Strikha, sent an appeal to the European Physical Society, APS, and others to help the displaced physicists currently being relocated in various labs and classrooms outside the war zone. Many of our colleagues from the Donbas region are currently located in various labs and classrooms outside the war zone. Donetsk State University, one of several universities evacuated from Donbas, has been reorganized in Vinnitsa, some 300 miles from Donetsk, where faculty, their families and over 1,000 students are temporarily living.

Amy Flatten, APS Director of International Affairs, has responded to the appeal. "APS develops outstanding outreach and education materials that can respond to requests by the Ukrainian Physical Society. In addition, we will offer free APS membership though our Matching Membership program and will partner with the APS Forum on International Physics and Committee on International Scientific Affairs to leverage other resources for Ukrainian colleagues," says Flatten. APS has also discussed partnerships with CRDF Global that can help bring Ukrainian physicists to the United States for workshops tailored to both new and experienced faculty in physics and astronomy.

CRDF Global, a U.S.-based nongovernmental organization with an office in Ukraine, organized a symposium at the recent American Association for the Advancement of Science (AAAS) annual meeting, bringing to California Ukraine's Minister of Education and Science, Serhiy Kvit, and Nataliya Shulga of the Ukrainian Science Club. Kvit spoke not only at AAAS but at Stanford University, the San Francisco World Affairs Council (www.worldaffairs.org/media-library/event/1416-.VPTnEi7K9YU), and at several private gatherings to call attention to the dire situation of Ukrainian science.

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Programmable Materials

By Michael Lucibella

APS March Meeting 2015 – Physicists are finding new ways to dramatically alter the mechanical properties of a material by changing its physical form. Researchers at the March Meeting in San Antonio showed how they are developing ways to control the compressibility of elastic materials.

"We can engineer the energy absorption by engineering the structure," said Katia Bertoldi of Harvard University.

The materials that she's developing can dissipate the force of a collision better than naturally-structured materials can. Introducing a lattice of regular, round voids into blocks of ordinary rubber fundamentally changes how it reacts to an impact.

"I can deform it very fast or very slow, the response is going to be the same. This is not the case for most of the materials currently used," Bertoldi said. "Another interesting feature is that it's scale independent … I can make it very small, or I can make it very big. I can make it meter scale or I can make it nanometer scale."

When compressed, the block's normally-round cavities abruptly collapse into horizontally- or vertically-aligned ovals. This rapid switching helps to dissipate the impact, but serves also as a way to design customized materials with different compliances.

Bertoldi showed an example in which a truss-shaped structure collapsed down after a threshold of force was applied. An egg cushioned by the truss was intact after a two-foot drop, a feat that a solid block couldn't perform.

Bastiaan Florijn of Leiden University added another variable to the mechanical programming of materials. He too is working with blocks of elastomers with circular holes, and he found a way to further customize how they behave. He placed pins on the side of the blocks to control which holes compress and in what direction.

"It's just a slab of rubber with holes of different sizes," Florijn said. "We use just these simple clamps on the side of the matter to confine the compression in the horizontal direction."

Like Bertoldi's egg demonstration, the material stays rigid until it encounters a threshold level of force and then collapses down abruptly, dissipating much of the impact in the process. The pins along the block's sides program how much that threshold force is.

"Just by changing the confinement in the horizontal direction, we can change the mechanical response," Florijn said. "We don't need to have a lot of different materials, [you] can use just one material and get all of this very exotic behavior out of it."

Moreover, this process is reversible. Even after a crushing collision, pulling on the elastomer block will pop it back into its original shape, with its original properties unchanged. "Our system is still intact, and our system is still elastic," Florijn said. "We can, for example, imagine using this material to make a car bumper."

Using pins to control the flexible structure's deformation is an early step towards designing truly programmable mechanics into materials. Already Florijn and his team are working on designing a three-dimensional material that can crush down from any direction.

Physicists Look at Animal Behavior

By Shannon Palus

APS March Meeting, San Antonio — As Imperial College London physicist Andre Brown reminded his audience at the APS March Meeting 2015, Kepler's laws of planetary motion accurately describe the way that the planets move around the sun. Brown, who studies worms, wonders: Could there be such laws for animal behavior too?

Today, any comparison between the depth of understanding of animal behavior and detailed knowledge of solar system kinematics may seem silly. But three focus sessions on the physics of behavior showed that tracking and modeling animal motion still bears fruit.

A computational model for the predator-prey dynamics of bacteria: Bacteria can be useful for producing biofuels, or cleaning up an act of biological warfare. If there is a uniform concentration of food, they exhibit Brownian motion. A new model, presented by Steve Pressé, a physicist at Indiana University – Purdue University Indianapolis (UPUI), illustrates how microscopic predators can go on a targeted mission.

Although the path of a single organism toward a point-source is not uniform, it is not random. Instead of assuming the bacteria travel along a nutrient gradient, the new model proposes that they take a squiggly path toward a food source (simplified in the model as a single point). The bacterium senses the "prey," and after some delay, uses that information to swim in a new direction. "What [we] can infer is that when bacteria move, they have memory," says Hossein Jashnsaz, a Ph.D candidate at IUPUI who worked on the research.

From the model, which is applicable to all bacterial species, the researchers can infer a constant for the minutes that it takes to get used to a new environment, called "adaptation time." That time likely varies from species to species.

High-resolution cameras keep an eye on worms: A worm's repertoire is simple: it wiggles back and forth, explains Brown. But behavior of the 300-neuron dirt-dweller proves that marrying genetics and kinematics, even at its simplest, is tricky. The details of motion are hard to identify without extensive observation time. He presented a multi-worm tracker system that will record the motions of nearly

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What Makes a Physicist?

By Shannon Palus

APS March Meeting 2015 – How do you spot the physicists at a cocktail party? What do they wear to work, and what do they do when they get home? To a packed room at the March Meeting — some attendees in jeans, some in dresses, some in heels, some with thick-framed glasses and blunt stylish bangs, and many crowding in the back, standing — three researchers painted a picture of what it means to be a "physics person" with surveys, interviews, and an anthropological study of a physics department.

They each repeated the same observation: Physics largely seems stuck in a state of maleness. Each year, just 20 percent of all physics bachelor's and doctoral degrees are awarded to women. The field is very white, too: There are fewer than 75 African American and Hispanic female physics and astronomy faculty in the entire United States. A feeling of belonging is what often separates talent that stays in physics from talent that stays out, recent research underscores. And it goes beyond those who end up pursuing a physics career: Skills learned from taking even just a handful of college physics courses are highly useful in a number of fields.

In a survey of 6,772 undergraduate students from all majors, Florida International University researcher Geoff Potvin quantified the underpinnings of the "physics identity," and connected it to the likelihood that a student will pick physics as a career. He explored three main factors: performance, interest, and recognition.

As expected, interest in physics is correlated with a strong physics identity. But for women, competence in physics was slightly negatively associated with the identity. "Just doing well is not enough," Potvin explains.

A student's feeling of belonging — an example of what Potvin calls "recognition beliefs" — was the number one predictor to whether or not a student, of any gender, would go on to study physics. Recognition can come from teachers or peers; it can be as simple as an acknowledgement of a strong performance in a lab or on an exam.

That praise needs to accumulate to translate to a strong sense of belonging, said Michigan State University physics education researcher Vashti Sawtelle. "It is insufficient to have one positive experience." Sawtelle offered the session's refrain: "The data that I have is sad."

To look at the specifics of what might alter the physics identity for students and faculty of different genders, McGill University educa-

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Washington Dispatch

Updates from the APS Office of Public Affairs

POLICY UPDATE

President's Budget Request

The President released his Fiscal Year 2016 (FY16) budget request (PBR) in February and it was predictably dead on arrival. In fact, some members of Congress were already criticizing the request before it was officially released. As a start to negotiations, however, the President's budget request (PBR) made clear that the Administration prioritizes biomedicine, energy efficiency, climate change, advanced manufacturing, and science, technology, engineering, and mathematics (STEM) education.

For instance, the PBR proposes funding the Department of Energy Office of Science (DOE SC) at $5.34B (+5.3%), within which Fusion Energy Sciences would receive a 10.1% cut, whereas Advanced Scientific Computing Research would receive a 14.7% increase (part of which would be devoted to crosscutting climate change research), Energy Efficiency and Renewables a 41.7% increase, and the Advanced Research Projects Agency-Energy a 16.1% increase.

The PBR for the National Science Foundation (NSF) reflects the same priorities. Proposed NSF funding is $7.7B (+5.1%). The Education and Human Resources directorate would receive the largest increase at 11.1%, whereas the Mathematics and Physical Sciences (MPS) directorate would see an increase of 2.2%. Within MPS, Physics would receive a boost of 0.9%, Astronomy would rise by 1.0%, and Materials Research would rise by 3.0%.

The Department of Defense Basic Research (6.1) account would be cut 7.9% in the PBR, although the Applied Research (6.2) account would receive a 2.1% increase. The National Institutes of Standards and Technology (NIST) would receive $1.12B (+29.6%), with the Science and Technical Research Services account increasing by 11.7%. NASA Science would receive $5.29B (+0.9%) and the James Webb Space Telescope would be funded at $620M for FY16. The National Institutes of Health would be funded at $31.3B (+3.3%), with much of the increase going toward the President's precision medicine initiative.

Congressional budgets are expected to adhere to the strict caps set forth by the Budget Control Act of 2011. These caps are $71B below the PBR, split evenly between defense and non-defense.

Chairman Smith and the National Science Foundation

Since taking up the gavel as chair of the House Committee on Science, Space, and Technology, Rep. Lamar Smith (R-Texas) has consistently attacked what he sees as wasteful spending at NSF. Chairman Smith has on multiple occasions tried to advance legislation opposed by the science community, such as the High Quality Research Act and the Frontiers in Innovation, Research, Science and Technology (FIRST) Act.

While no legislation has passed, the NSF has reacted to Mr. Smith with a series of reforms including the most recent: emphasizing that titles and abstracts of grant proposals need to be written to be easily accessible to the general public. Or, as Mr. Smith put it, "as a public justification for NSF funding."

At a recent hearing France Cordova, director of NSF, stated she supports the policy provision requiring each grant funded by the NSF to be verified to be in the national interest. APS remains concerned that such a provision might at best be a meaningless waste of time as a checked box and, at worst, limit flexibility to pursue the most interesting scientific leads during a research project. Such flexibility has been a hallmark of NSF and a distinguishing feature of grants as opposed to contracts.

Upcoming Legislation

Work on the Elementary and Secondary Education Act (ESEA) continues, and staff expect bipartisan support once the bill is finished. Sen. Alexander's (R-Tenn.) office released a draft version of ESEA for a public comment period, which has since closed. The draft version of the bill generally shifted responsibility for achievement from federal to state government. After the public comment period closed, staff from both the majority and minority have been working to refine the draft and meet stakeholder input. Expectations for passage this year remain high.

WASHINGTON OFFICE ACTIVITIES

MEDIA UPDATE

Science Magazine and *Chemistry World* recently published stories about a research bank proposal that could shore up funding for science. APS Director of Public Affairs Michael S. Lubell and Tom Culligan, vice president of the The Brimley Group, developed the idea. The stories can be read at the following URLs: http://bit.ly/1MuANDc and http://rsc.li/18DKX7i

PANEL ON PUBLIC AFFAIRS

The draft Statement on Earth's Changing Climate, described in the insert of this issue of *APS News*, is open to the APS membership for commentary. Please check your email for a link to the statement and the comment site.

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Sole Physicist in Congress Prepares to Defend Science

The only physicist in the U.S. Congress is joining the House Committee on Science, Space, and Technology. Representative Bill Foster (D-Ill.), who holds a Ph.D. in physics and formerly worked at Fermilab, announced on Wednesday that he was appointed to serve on the committee.

"As a scientist, I know firsthand how important it is for the United States to sustain our position as the leader in science and technology," Foster said in a statement. "Serving on this committee will allow me to better advocate for sustained investments in research and development and support Illinois's national laboratories."

In Congress since his election in 2008, Foster previously had focused much of his attention on financial reform. In an interview with *Science*, he said that he wanted to counter some of the "attacks" on science he's seen coming from the committee in recent months.

Foster's announcement comes as the chair of the committee, Lamar Smith (R-Texas), pursues inquiries into about sixty grants issued by the National Science Foundation, a number of which he referred to as "questionable." The chair's actions sparked controversy and led to accusations of political attacks on research from the scientific community.

Before being elected to Congress, Foster was a high energy physicist at Fermilab for more than twenty years. He helped design particle accelerators and was a part of the team that discovered the top quark in 1995.

Bill Foster

NSF and Congress Seek Rapprochement

By Michael Lucibella

A new policy of the National Science Foundation (NSF) might settle the ongoing feud between the funding agency and the House of Representatives Science Committee over Congressional oversight of its grant-award process. In December 2014, NSF formally adopted new rules requiring non-technical explanations and justifications for new grants.

The new requirements update NSF's Transparency and Accountability policy. Future proposals must include a nontechnical description of the project, an explanation of its significance, and a statement of how the project carries out NSF's mission, including the advancement of science.

At a subcommittee hearing in February, Chair Lamar Smith (R-Tex.) highlighted the similarities between these new requirements and ones in the Frontiers in Innovation, Research, Science, and Technology Act, commonly known as the FIRST Act, which was introduced in the House in March of last year but never passed.

"It appears the new NSF policy parallels a significant provision of the FIRST Act approved by this committee last fall," Smith said. At the hearing, NSF director France Córdova stated, "We completely agree that [it] is very important that the public understands the investment that this country is making in science and engineering and STEM education."

Though similar to NSF's new approach, the requirements outlined in the FIRST Act also explicitly highlighted the need for a grant to promote the country's economy or national defense. Smith referred to "… [a] requirement that NSF publish a justification for each funded grant that sets forth the project's scientific merit and national interest."

The National Science Foundation declined to comment for this article.

Tensions between the committee and NSF have been simmering since April 2013, when the Republican-led committee started requesting NSF documents about its grant review process. At the time, committee chair Smith called a number of the awards "questionable," and his requests focused primarily on grants from the Directorate for Social, Behavioral, and Economic Sciences, as well as grants related to climate change.

More recently, the committee seems to have expanded the scope of its inquiries. The committee's latest request for information targets more physical science, math, and engineering grants than before. In mid-February, the committee requested information about the grant review process for 13 grants from across the foundation's research programs.

In addition to grants about climate change, the most recent group of targeted grants includes research aimed at protecting power grids against cyber attacks, detecting malware, and mitigating the effect of space weather on the global positioning system. Beyond the sciences, the committee requested no new documents from any grants in the social, behavioral, and economic directorate.

According to a committee aide who asked not to be identified, a grant shouldn't necessarily be considered "questionable" just because the committee requested more information on it. He said the committee is broadening the scope of information requested in order to get a better handle on the more technical grants.

"Because composition of an understandable, non-technical description may be more difficult for complex projects and perhaps particularly difficult for some projects in the physical sciences, the committee wanted to look at complex projects from each NSF research directorate," the aide said in an email.

Allan Weatherwax, a plasma physicist at Siena College in New York, finds this explanation plausible. He said that if he were to put together a cross-section of NSF grants, the lineup might not look that different from what the committee selected. "It's an eclectic list," Weatherwax said. "I looked at them and I saw no common theme in the proposals."

His is one of the proposals that the committee is currently reviewing. He researches Earth's magnetic fields around the poles and how the aurora can sometimes disrupt GPS systems. Though initially surprised to hear that his grant was being reviewed, he's not concerned about the inquiry or any potential effects it might have on his reputation. "I'm using taxpayers' dollars, and I think our work is outstanding," Weatherwax said. "It's [Congress's] prerogative to review our work."

Alexander Teplyaev, a professor of mathematics at the University of Connecticut, thinks it was likely random chance that his research on fractals caught the eye of the committee. "I don't have specific reasons to be concerned because of this investigation," Teplyaev said in an email. "I had to reevaluate what I am doing, and I feel [I] am still on [the] right track."

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CRDF Global is consolidating funds from private sources to support scientists in Ukraine. Among their many efforts, they are working to identify, procure, and transport new or used equipment to displaced physics, chemistry, and biology departments, and seeking to provide emergency research funds. Those interested in helping should contact CRDF Global's Ukraine team (Ukraine@crdfglobal.org).

I urge my fellow APS members to reach out to our Ukrainian colleagues. As an organization, APS can help by offering a variety of tools and technical assistance for the affected scientists to function in their temporary environment. However, all of us individually can offer moral assistance by reaching out and making contact with Ukrainian colleagues. You can do this through the UPS office (ukrphysicssos@ukr.net) or individually if you have friends there. The UPS has organized a task force to provide assistance to the displaced physicists. Additionally, many Ukrainian scientists have recently immigrated to the U.S., including young people who came here to study and are currently at U.S. universities and industry. Urgent help is needed and I ask you to reach out.

George Gamota is a former professor of physics at the University of Michigan, a former director of the Department of Defense research program, and founder and president of STMA LLC. He is an APS Fellow, an honorary member of the Ukrainian Physical Society, and a foreign member of the Ukrainian National Academy of Sciences.

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ting a current through the device adjusts its resistance, and therefore the strength of connections through it. An array of these "artificial synapses" would link sensory signals with motor "neurons."

In a simulation of the array, IBM researchers made the neurons spike randomly, causing random movement of a simulated Roomba-like robot. Like a flailing baby, the robot ambles around. Some movements bring the robot closer to a target, eliciting a positive sensory response. When a sensory neuron and a motor neuron fire together, they decrease the resistance of the device and have a stronger connection, explains Kim.

But it can only be scaled up so much. To Adami, it's not a question of better hardware components. Neuroscientists don't yet understand the whole brain fully enough to render it in hardware, Adami points out. Instead, he asks, "Can Darwinian evolution create sentient [artificial] brains?"

In simulations, thousands of sets of robot brain "genes" each determine a different network. Each brain is put in a simulated robot, says Adami, where it controls the robot and tries to keep it alive. "At the end of the process we transplant the best brain — or brains — on to real robots," he explains. It's a kind of natural selection in an artificial system.

He has already used the process to create a simple robot that can stay inside a circle. He envisions that the process can work for very complex, multipurpose machines. "When we turn them on, they will be infants," Adami says of highly evolved brains. "We may have to wait 10 years, or 15, until they are worth taking seriously."

One government agency doesn't want to wait that long. The Defense Advanced Research Projects Agency (DARPA) is pushing robots to do useful things now. According to DARPA program manager Gill Pratt, the agency will host the DARPA Robotics Challenge in Pomona, California in June 2015. Created in response to the Fukushima disaster, the challenge offers $2 million in prize money for the team with a robot that can best complete a series of basic search and rescue tasks.

The 25 humanoid contestants will have to drive to a disaster zone, traverse tough terrain, move debris, cut a hole in a wall, adjust a valve, climb stairs, and then complete a surprise task. These robots will have supervised autonomy: A human controller can assign tasks and override the robot's choices.

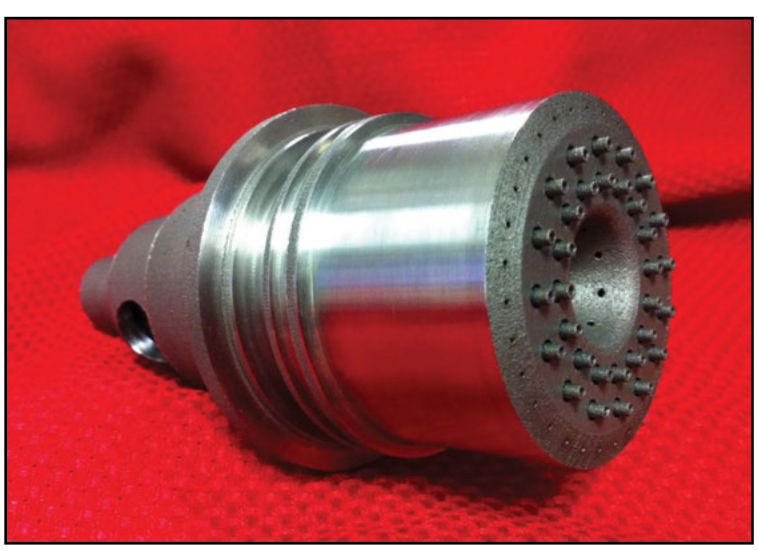
And poor choices by artificially intelligent robots could be a problem. University of California, Berkeley computer scientist Stuart Russell expressed concern that fully independent robots will make bad decisions — from a human, and moral, point of view — about how to complete tasks. Last year, Russell co-wrote an opinion article with Stephen Hawking, because they thought a question about sentient robots raised by the sci-fi box office flop *Transcendence* — Could a hyperintelligent machine become an unstoppable force against humanity? — "deserve some serious thought."

If you ask a robot "to do something as simple as make some paper clips, or calculate digits of pi, well, if that's the only thing you ask, it's going to come up with ways of doing that optimally, which might involve converting all of the mass of planet Earth into computational facilities," says Russell. "Clearly that's not what we want."

But Pratt's vision for the smart robots born from the DARPA challenge paints a hopeful picture for AI. As he explains, "It's robot and a person working as a team, each trying to do what they are best at."

And Adami personally thinks that robots may grow adept and clever, but never more intelligent than humans: "We are going to be their teachers, in the same way that we teach our children."

REVOLUTION continued from page 1



NASA

The promise of additive manufacturing also includes the peril of easy-to-make weapons, as illustrated by this 3D-printed rocket engine.

tric is aggressively pushing the technology into its manufacturing lines. "We are taking the leap into industrial additive manufacturing," Singh said. "We are starting three new facilities for the industrial use of these materials."

Medical applications are also just starting to appear. Creating custom implants and prosthetics for patients could potentially revolutionize medical treatments. Such 3D-printed body parts are subject to the same U.S. Food and Drug Administration (FDA) regulations as devices manufactured through traditional means. Already more than 70 applications have been approved, including skull plates, spinal trusses, and even whole jawbone replacements.

The portability of smaller 3D printers, some not much bigger than a microwave oven, could help bring advanced treatments to areas underserved by the healthcare system. "Think of what that might mean for mobile hospitals, for example," said Katherine Vorvolakos, a chemical engineer at the FDA. "Production can conceivably happen anywhere."

However, experts caution that shrinking the footprint of manufacturing has a dark side, one with potentially global ramifications. "The downside to all of this is that it could dramatically increase [nuclear] proliferation and make it harder to detect," Goodwin said.

Nonproliferation monitors have long used the large scale of the nuclear weapons industry to track proliferation around the world. Not only do the nuclear facilities themselves take up large areas and resources, but the manufacturing efforts to build bomb parts do as well. "Waste stream elimination eliminates one of the major indicators and warnings of proliferation," Goodman added.

Advances in metal printing techniques like direct-metal-laser sintering could be used to fabricate a variety of weapons. Goodwin highlighted an instance where he downloaded from the Web the build file for an unnamed part to a nuclear reactor and printed it out. Using traditional fabrication methods, the part would have required 168 welds and several months of work to set up an assembly line. "We made that part out of stainless steel in about four hours," Goodwin said. "In 15 years, this will be a nightmare."

This has significant implications for the control of conventional weapons as well. 3D-printed handguns have made headlines already, but Goodwin said that the problem could be bigger. General Electric routinely prints aerospace-grade components for jet engines, a technology that could potentially be adopted to produce the parts to build whole jet fighter planes.

He added that digital build files, the essential data telling printers how to construct an object, shifts the problem of import control into the cyber realm, an altogether more complicated paradigm. It is difficult to completely stem the flow of digital information, potentially making it easier for an unfriendly country to simply produce a product itself in order to circumvent restrictions on the importation of banned technology, such as parts for nuclear weapons.

"The downside of this is that it could essentially eliminate the use of trade sanctions for foreign policy," Goodwin said.

So far, no one has demonstrated a way to 3D-print fissile materials, but it's likely there are no fundamental barriers to building a device that prints uranium or plutonium. International controls of such materials have so far prevented anyone from developing such techniques.

"Controlling the materials is the most important thing," Goodwin said. "[But], I think you have to assume that any system of control is going to break down."

DIRECTOR continued from page 1

the future. I've been also engaged in consulting activities for the Department of Defense and very active in nuclear security. A few years ago, I ran a National Academies study on technical issues for the conventional test ban treaty. I'm really proud of that report because we did a very serious technical review of those issues and really put a baseline in place for decision makers to understand what was out there in terms of ability to monitor the test ban treaty.

AGL: What were the results?

EW: The results were that when you're [trying to sense] if someone's … [set] off a nuclear [explosion], you can detect tests at different levels with different levels of confidence. So if someone is doing a test at the large scale, which would be necessary to create a highly-advanced type of nuclear weapon, we believe that would be detectable. If someone was doing very crude development, a very simple nuclear weapon, that might not be detectable. So you'd really have to be balanced in your issues of understanding what it is you're looking for and what the risks are in assessing what the meaning of detection was.

AGL: What are you excited about at ARPA-E, and what are the important projects that you and your team are working on?

EW: I'm excited about ARPA-E because of the technical innovation, and the challenge of the problems we're trying to solve. The whole energy challenge is so important to society. And I'm excited about ARPA-E because of the real potential for impact. The unique thing about ARPA-E's model is that we combine technical innovation with really a cold eye, razor-sharp focus on making sure that the technologies we develop are actually on a pathway to being competitive in the marketplace. And that's what makes ARPA-E different and it's going to allow us to have a continuously expanding impact.

AGL: What are the transformative technologies that are in energy research at the moment that will have or could have the biggest impact, and how is ARPA-E playing a role with that?

EW: I think heat capture is huge. We waste so much of our energy having it go off as heat. Energy storage — that one is, again, a huge issue for stabilizing the grid, allowing distributive generation, allowing more integration of renewable energy resources. It's interesting that when people tend to think of energy storage, they think batteries, and we've invested a lot in batteries, but batteries is not the only approach. In the end, we're not going to be the ones who decide what happens in the actual implementation in the world, what we're going to do is put the technical options forward and those will then be available to see what the best fit is for the needs and politics of the future.

AGL: How is energy research changing, and how is ARPA-E helping to facilitate that?

EW: I would say that at the mountain view, energy research is changing by [having] a much greater focus on all the different aspects of the energy system. How [everything] works together is becoming much more part of the planning, as opposed to just looking at oil, just looking at solar, wind, gas. The systems aspect of energy is becoming much more important in energy research.

AGL: So in other words, you see oil and gas experts working directly with professionals in solar, wind, biofuels, and so forth?

EW: To some extent, but maybe more than that, in terms of energy policy and planning, understanding how those things fit together. And how they can fit together in the future.

AGL: Do all ARPA-E funded projects have a timeline in terms of investing in research and converting it into a product?

EW: Our operational model is very much focused on a set of milestones which we negotiate with the project teams. So initially when we set out a focused opportunity announcement, it has in it a set of goals, both technical goals and market-readiness goals. And then when the proposals come in and we assess them, we work with the teams and we set up milestones to identify what they will have to meet if they are going to meet their goals within the two-to-three years of the grant. And that's a really productive way of doing research and it's something that ARPA-E has pioneered and developed.

AGL: How is ARPA-E collaborating with other nations and with traditional oil and gas companies?

EW: I would say that our engagement with other countries is in the idea exchange. How do we really do business, how can the ARPA-E model help them, and what can we learn from their ways of doing business and what their problems are? That's been a really interesting focus for us. In terms of oil and gas, we definitely have an "all of the above" approach, as per the Administration, and we have our three mission goals, which are reducing emissions (including greenhouse gas emissions), improving energy efficiency, and reducing dependence on energy imports.

AGL: How would you advise physicists who want to become more active in energy research, or ARPA-E activities?

EW: I would advise physicists to be open to the idea of getting engaged with a big collaborative team and pulling their cutting-edge great idea into something that has applications. You need to step out of your comfort zone and bring your physics into the development process.

AGL: Anything else you'd like to share with the readers?

EW: Well I've been a member of APS for a long time and so I'm delighted to be here as a physicist. And as we've been talking about, a physics background is wonderful preparation for working throughout the energy industry and addressing the impacts and the problems our society faces.

Alaina G. Levine is president of Quantum Success Solutions, a science career and professional development consulting enterprise.

ANNOUNCEMENTS

Notice to Members:
APS Annual Business Meeting, April 10, 2015

On April 10, 2015, the American Physical Society will hold its annual business meeting. The meeting will be held at **4:30pm in the Hilton Baltimore Hotel** just prior to the start of the APS April meeting 2015. Members may participate in person or electronically.

For more information visit: /www.aps.org/about/governance/meeting.cfm

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tion researcher Allison Gonsalves spent seven months in 2007 embedded in a physics department at a large North American university for her doctoral dissertation. She published some of that work in her 2014 paper, "'Physics and the girly girl—there is a contradiction somewhere: doctoral students' positioning around discourses of gender and competence in physics."

For her research, Gonsalves asked graduate students to keep photo diaries of what it meant to them to be a physicist. They brought her snapshots of tea and cookies from department meetings, and of machines. One woman took a picture of her toilet, and explained that she had fixed it. A physicist, she explained, can fix things. "Being a good physicist entails performing physics," says Gonsalves, "just in the same way that gender involves repeatedly performing things that signal our gender."

The way that gender wraps into that identity came in her interactions and interviews with graduate students. After a tour of the scanning tunneling microscope, one told her that women rarely use the machine, joking: "We'll have to perform a cleansing ceremony when you leave."

In an interview, a female grad student told her: "People don't wear dresses, people don't wear high heels" she told Gonsalves. "If I did those things, I would feel out of place."

That student's fears were echoed in a panel at the end of the session in San Antonio. One leader of a women-in-physics group noted that their group had a discussion about whether or not it is appropriate to wear high heels — regarded by most of North America as a standard option for business casual office wear — to an interview. On the reddit.com discussion website, one thread about the March Meeting gave gendered advice on what to wear. One entry suggests flip flops. But when casualness is linked to gender, it may not be as accepted: Another entry warns not to wear a skirt that's too short, lest the wearer not be taken seriously.

Those stereotypes are knit into who students consider to be a physicist. In research published in 2009, Potvin found that female teachers received lower evaluation ratings, on average, than their male counterparts — regardless of actual classroom behaviors. New research from Potvin paints a "worrying picture": Students who score higher on the physics identity scale exhibit bias against female teachers more strongly.

There's little consensus on how to attract more women to the field of physics. In a survey of 7,505 students, Potvin looked at the effects of several approaches: single-sex classrooms, women-scientist guest speakers, role models, and discussions of the problem. Discussing the issue of underrepresentation was the only method that increases the likelihood of pursuing a physics career.

For Gonsalves, looking at gender alone is not sufficient. "If you are really truly going to understand peoples' experiences, you need to use a more intersectional lens." That means taking forces like race and class into account, and expanding the diversity issue beyond just women in physics.

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The POPA Physics & the Public Subcommittee continues its work on a survey focused on overcoming the obstacles of recruiting teachers in the physical sciences. Two proposed APS Statements, one a revision of the APS Statement on Civic Engagement and the second on the Status of Women in Physics, will be made available for APS membership commentary later this year.

The POPA National Security Subcommittee is considering a proposal for a study, to be held in partnership with the Ploughshares Fund, on non-weapons science conducted at the nation's national security laboratories.

The POPA Energy & Environment Subcommittee has received approval for a study examining ways to address the long-term challenges of helium supply and pricing. As a way to address nearer-term challenges, the APS Office of Public Affairs continues its pilot test of a "helium brokerage" to help APS members manage helium supply delays and price spikes.

A template for study proposals can be found online, along with a suggestion box for future POPA studies: www.aps.org/policy/reports/popa-reports/suggestions/index.cfm.

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200 worms around the clock — a substantial upgrade to the single-camera system that he used before.

The sliding six-camera system captures how fast the worms move, and how often they turn — their "roaming and dwelling" behavior — while recording unexpected, repeated motions. Six cameras generate 2 terabytes of raw video per hour, so to save on storage space, the system identifies the worm's motion and records it, while suppressing the background.

Eventually, Brown hopes to link the worms' wriggling to their genetics and neuronal activity. For now, Brown is glad to have the upgraded instrument: "We're really just at the stage of collecting good quantitative data."

A standardized environment for burrowing creatures: The long bodies of snakes and lizards come in handy when they need to burrow into sand. Dry sand is easy to replicate in a lab but wet sand — which clumps together — is more difficult. Georgia Institute of Technology physicist Daniel Goldman presented a new method for creating a wet sand environment in a lab, and demonstrated its usefulness in revealing an environmental limitation of Ocellated skink movement. The new method "allows us to create repeatable homogeneous conditions," Goldman explained.

He and his team made a wet granular mixture with water and dry spherical glass particles (each with the same diameter), blended with a kitchen mixer.

The team used an x-ray camera to observe the skink as it burrowed in both dry "sand," and the new wet "sand" environment. In the wet material, there was a limit to how deep the animal could go. Using a cylinder as a proxy for the animal, Goldman found that the wet material was three times more resistive: In the wet material, the animal has to work to disrupt the liquid that holds the sand together.

Dead frozen diving sea birds show how it's done: Virginia Tech physicist Sunny Jung wanted to know how seabirds can make fast dives into water but not break their necks. A good example is the gannet, a long-necked bird that can enter the water at 55 miles per hour.

Jung froze specimens of dead gannets in the elongated diving position. Researchers dropped the frozen birds into tanks. When a gannet is partly submerged, the drag from the water pushing up, and the downward pull of gravity act as compressing forces. A video camera captured the birds' entrance into the water, and revealed that a protective cavity of air forms around their necks, like an underwater air bag.

To better understand the forces involved, Jung created seabird proxies, with cones for heads, connected to spherical bodies by elastic bands of varying length. He's building on the work with a study of what happens to human necks in extreme diving, which can lead to multiple fractures.

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to release the report this coming summer and plan to include a list of best practices that research institutions can adopt. In the works for years, the report comes after a number of recent high-profile retractions over misconduct, most notably the stem cell controversy coming out of teams from Harvard and RIKEN.

"There's really only been, relatively speaking, a few cases," said Robert Nerem of the Georgia Institute of Technology, and chair of the committee. "Even so, the media attention very much weakens the public faith in the reliability of scientific research."

The extent of scientific misconduct is difficult to pin down precisely. In 2013, the last year that numbers are available, about 500 research articles were retracted out of the more than 1 million published across all scientific disciplines. I don't think the statistics begin to capture the amount of scientific misconduct," Wolpe said.

He pointed to surveys of scientists conducted by several investigators, including Martinson, which indicate between 5 and 33 percent of scientists admitted to knowing of someone who falsified their work in some way. Nearly 2 percent admitted to doing it themselves at some point during their career.

"That is implying a much higher rate of scientific misconduct than we normally appreciate," Wolpe said.

In addition, the number and rate of retractions has been rising over the last two decades as well. "It might be heartening because what it might mean is not more misconduct, but more vigilance, and lets hope that is in fact what we are seeing," Wolpe said.

The committee is in part drawing on current social psychology research that looks at the motivations for improper behavior. Their approach puts a new emphasis on the influence that an institutional environment can have on a person's actions.

"As we learn more, all the time, about the cognitive biases, the fallacies, the pressures, the incentives, and in particular the environments in which we operate, it means that we have to think a little differently about how we protect ourselves against the errors to which we are all prone," said C. Kristina Gunsalus of the National Center for Professional and Research Ethics.

She added that individuals tend to give into temptation when they and their peer groups are overly ambitious, promote a sense of entitlement, or work in obtuse systems with inefficient rules.

"The amount of cheating which humans are willing to engage in depends on the structure of our daily environment," Gunsalus said. "It is always possible to rationalize something scummy you want to do."

The committee hopes that by highlighting these root causes and laying out best practices, it will begin an effort at research institutions to identify and address problems in their working atmosphere.

"Either the scientific community [and] the research community address these problems, or the government will," Nerem said. "Government intervention in my opinion would not be desirable, and I suspect that's true of everybody in this room."

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Reflections on the Fifth International Conference on Women in Physics

Chandralekha Singh

In August 2014, I attended the 5th IUPAP International Conference on Women in Physics (ICWIP 2014) in Waterloo, Canada as part of the U.S. delegation. The conference was attended by approximately 215 female physicists and a few male physicists, all from 49 different countries. There were research talks, panels, workshops, breakout sessions and posters on issues related to women in physics.

A major focus of the conference was how to address the many barriers that uniquely affect the advancement of women in physics worldwide. Barriers that were listed in the country reports included societal biases affecting women and accumulating over time from an early age, unconscious gender bias, and the effects of stereotypes. Also contributing are family responsibilities, unfriendly and unsupportive environments in physics departments, lack of mentoring, lack of a critical number of women in physics and lack of role models. Compared with other professions that women might choose, physics is perceived to be especially competitive rather than collaborative. Physicists generally do not try to explain to their students how physics helps humankind. Male physicists in some countries have a reputation for acting "macho," leaving women physicists feeling marginalized. In some countries, e.g., in the Sudan, issues that negatively impact and limit women's ability to begin and sustain careers in physics also include religion, economics, and politics.

In the conference workshops, we learned what social scientists have ascertained about how girls are influenced as they grow up with regard to pursuing science and mathematics. In the workshop, "Equity and education: Examining gendered stigma in science," we learned that, while most girls are interested in science and math when they are in early grades, in countries like the U.S. many tend to step away, often because they unwittingly conform to societal gender stereotypes. Women in some countries like the U.S. are often victims of gender stereotypes from very early on, and some women are impacted so much that they even start questioning their own ability to ever be equal to or better than men in STEM fields.

"In some countries such as the US, when women don't succeed in a science course, people often attribute it to their poor abilities; but when men do not succeed, people often attribute it to their lack of effort or poor teaching, but not to their lack of ability."

Societal biases related to women not being smart enough to pursue careers in male-dominated STEM fields can impact women's beliefs about their own capability and negatively influence whether women pursue STEM majors and how they perform in STEM courses. In some countries such as the U.S., when women don't succeed in a science course, people often attribute it to their poor abilities; but when men do not succeed, people often attribute it to their lack of effort or poor teaching, but not to their lack of ability. This dichotomy has a negative impact on whether women who have failed once would want to pursue those subjects in the future ("failing" could even be obtaining a B or a C grade in a course for an otherwise high-achieving woman). Many women in male-dominated fields assume that small setbacks, e.g., getting one B or C grade in a physics course, are indicative of their lack of aptitude for physics. They are more likely to interpret such setbacks to imply that they are not cut out to pursue a physics-related degree and so they lose confidence. If women underperform, they are often likely to blame themselves and feel that they do not have the talent necessary for excelling in the subject in which their male counterparts seem to have an edge. In several studies, if students did not perform well in a test and were told that learning is about effort, they tried harder and did better later, but if they were told that learning is tied to innate ability, they did not try harder after they performed poorly.

Stereotype threat, e.g., directly or indirectly being reminded that women cannot do physics, can exacerbate the situation. Women become victims of stereotype threat when their performance is negatively impacted by their negative perception about the group — "women"— to which they belong. For example, just asking a woman to write her gender on the test sheet before she takes a test can act as a stereotype threat; also this can lead her to perform worse than she would otherwise. Writing her gender can act as a stereotype threat because women are already aware of the societal stereotype that women are not supposed to do as well as men in math and science. Such a threat often undermines a woman's ability to score high on tests or other standard measures of academic achievement. Research in some western countries such as the U.S. suggests that people often perform much below their level when pressured to conform to a stereotype.

Discrimination that women physicists face in the workplace is overt in some countries and in some cases subtle, and the differences are caused by how each culture views women. Women in physics in many countries are still often made to feel that they have chosen a wrong career path. Their success is overlooked. Their opinions are often dismissed even if they are worthy of further discussions. Women physicists from many countries in Africa, Asia, and South America reported that they even have to justify why they chose physics, despite being a woman, because of the macho culture and societal norms.

The "leaky pipeline" prevents women physicists in all countries from reaching the highest levels of our profession. The amount of leakage and at what stage it occurs varies significantly from country to country. In the U.S., women's participation in physics decreases precipitously from high school to college level and then again in the top leadership positions in physics. However, unlike the situation in many other countries, in the U.S., in the last decade, there is no leak from the undergraduate to graduate to assistant professor level in physics — the percentage of women at each of these levels has hovered around 20%.

"Regardless of the country, the common theme at the conference was that women are highly underrepresented in leadership positions and decision making roles."

Regardless of the country, the common theme at the conference was that women are highly underrepresented in leadership positions and decision-making roles. The overall proportion of female researchers in Estonia is over 40% and exceeds the European average, but the gender imbalance in the researcher population increases with age. Women physicists from some Asian countries, e.g., China, noted that everything was fine up to graduate school, and there was no significant barrier for women in physics until they obtained their Ph.D. After the Ph.D., there is a perception that women do not have the ability to be good physics professors, researchers, or scientific leaders, or that they should focus on their family rather than pursuing a high-profile career as a physicist. The glass ceiling was cited as a major factor why women fail to reach the top in physics across the world.

In 2012 the American Institute of Physics released the results of the Global Survey of Physicists, which was completed by 15,000 female and male physicists in 2009-2010, analyzed by regions, and restricted to 12 countries with sufficient data. Staff member Casey Tesfaye described how in nine of the analyzed countries, women had fewer opportunities than men, and in a different nine-country subset they had fewer resources than men. Regarding career progress, women with children progressed more slowly than men in eight of the analyzed countries.

Women physicists, especially, from some African countries, noted that taking an interest in physics is also perceived to diminish their feminine attributes. In fact, even in the U.S., the stereotyped portrayal of female scientists by popular media (e.g., the TV show "The Big Bang Theory") which make them look unattractive, does not help in encouraging more young girls to pursue physics. Eileen Pollack, who wrote an opinion piece in *The New York Times* (October 13, 2013) about why there are so few women in science, attended this ICWIP 2014 conference as a panelist and raised the point that the paucity of women going into physics is exacerbated by the stereotyped portrayal of female scientists.

"...the stereotyped portrayal of female scientists by popular media (e.g., the TV show "The Big Bang Theory") which make them look unattractive, does not help in encouraging more young girls to pursue physics."

Women physicists from Iran noted that more than 60% of B.S. and M.S. students, 47% of Ph.D. students, but only 18% of faculty members in the physics departments are currently women. These high percentages of female physics students are partly because men in Iran are often more interested in engineering, because the career prospects are better. Women from Egypt noted that the reason many women do not take comparable jobs to men, even after obtaining their Ph.D., is that they want to be closer to home in order to take care of their families, so they have lower aspirations professionally in order to balance work and family.

What was clear is that in many of these non-Western countries, the women physicists have greater difficulty balancing family and work. Not only are they responsible for everything at home, but in addition, childcare and flexible work hour options are much less common in these countries. Some of these women physicists seemed resigned to the fact that they are unlikely to get an opportunity to pursue a career in physics as rewarding as the one afforded to their male counterparts because they have to find a job closer to home in order to balance work and life. In some of these countries, efforts to provide opportunities to balance work and family, and counter-biases that exacerbate the difficulties, are impossible to even dream of at this time.

Even in western countries female physicists face challenges. The German contingent discussed data suggesting that female physicists' professional competence and accomplishments are less appreciated, and that parenthood affects their education and career distinctly more strongly than those of their male counterparts. Physicists from Finland (where the first female professor of physics was hired in 2004 at the University of Helsinki) noted that cultural reasons were central for understanding the gendered-career-segregation processes. For example, they noted that many major decisions are made in men-only saunas, which automatically excludes women physicists.

The good news is that in many countries, in the science and engineering departments where women are underrepresented, there is more awareness that there may be implicit and explicit biases that partly account for the underrepresentation of women. There is also more awareness that more effort should be devoted to recruit and retain talented women to ensure that everybody has an opportunity to contribute to the vitality of these disciplines.

You can hear the interesting and inspiring stories of some of the participants in the conference by watching a 14-minute video at this youtube webpage: http://youtu.be/ofE-mJFJR5w

Chandralekha Singh, is a Professor in the Department of Physics and Astronomy at the University of Pittsburgh and Founding Director of the Discipline Based Science Education Research Center (dB-SERC). She served in the Chair line of the APS Forum on Education 2009-2013.