Sidney Nagel Delights in Disorder
An interview with the recipient of the 2023 APS Medal.

BY RACHEL CROWELL

Nagel, who studies non-linear behavior in disordered systems that are far from equilibrium, is the recipient of the 2023 APS Medal for Exceptional Achievement in Research. The award recognizes Nagel for incisive experiments, numerical simulations and concepts that have expanded and unified soft matter physics.

But earlier in his career, his work was received differently. “Disorder wasn’t something to be studied,” he says. When he began studying sandpiles, he received a particularly harsh response. “I like to choose problems which satisfy me not just intellectually, but because Nagel continued on page 3

First a Bridge Program Graduate, Now a NASA Astrophysicist
Laura D. Vega has her eyes on the stars — the pulsating giants and red dwarfs, to be specific.

BY LIZ BOATMAN

astrophysicist Laura D. Vega remembers when she first fell in love with stars. She grew up in San Antonio, Tex., and her parents, originally from Mexico, often took the family on road trips to Coahuila and Zacatecas to visit relatives. On those long, overnight drives, Vega — peering out the backseat window — would watch the dark sky glitter.

“San Antonio is a big city,” she says. “You can only pick out the really bright stars … but in the desert, it’s just dark. You can really see the stars.”

Vega had questions — and she took them straight to the library. By sixth grade, she was tackling Stephen Hawking’s A Brief History of Time.

Vega continued on page 5

Study Reports the Impact of COVID-19 on Recent Physics Grads
Some undergrads, like those squeezed financially, were more likely than others to change their post-graduation plans.

BY LIZ BOATMAN

Wells Graham, a doctoral student in physics at Wake Forest University, knows all too well how dire the COVID-19 pandemic was for many undergraduates in science.

Graham graduated with a bachelor’s in physics in 2021 from the University of North Carolina, Pembroke, a small university. He says that although his professors did a “great job” of adapting to online teaching during the pandemic, conferences were canceled, and he was never able to take the physics GRE subject test — key to bimonthly up his graduate school applications.

“Coming from a small school, I was banking on the physics GRE to strengthen my application,” says Graham. “I felt I could not put my best foot forward.” He’s happy to have landed at Wake, but the process was difficult. He was accepted into just two of the seven physics graduate programs to which he had applied.

While some students, like Graham, stuck to their post-graduation plans despite the pandemic, others did not or could not. To study the issue, the American Institute of Physics (AIP) surveyed physics and astronomy seniors in the spring of 2021 about their post-graduation plans, and then again in the spring of 2022, to see if the seniors stuck to their plans. In November, AIP released their report, which captures the experiences of 1,823 seniors.

Annel Marie Porter, senior survey scientist at AIP and report co-author, says that her team sought to understand the factors that might push undergraduates out of physics.

“We asked about [students’] satisfaction with the different aspects of their institution’s response during COVID-19,” says Porter — including financial aid, learning accommodations, IT support for classes, access to mental health services, and on-campus living arrangements.

“We really wanted to focus on impacts that could have longer-term effects, beyond just a window into that time period.”

Porter and her report co-author Patrick Melwes, research manager of the AIP Statistical Research Center, found that about three-quarters of respondents did what they had planned to do after graduation.

For example, of the students who had intended to get jobs, 85 percent actually did, including Theo Astelli-Adams. Astelli-Adams, who majored in applied physics and mechanical engineering at the University of Wisconsin-Stout, says that completing his undergraduate degree during the height of the pandemic had ups and downs.

“Trying to learn in that environment and with such a different structure was difficult for me,” he says, referring to typically hands-on courses that the university pushed online. “Thankfully, I was able to complete an internship the following summer, and my capstone [project] happened the following year for me,” he says. Astelli-Adams is

Scientists Investigate Salty Stellar Recipes
In large collections of stars, sodium is far more abundant than expected. To explain this, scientists bring a stellar reaction into the lab.

BY MEREDITH FORE

II atoms began as the universe’s simplest ingredient: hydrogen. And when hydrogen is heated and mixed in the extreme environment of a star, complex nuclear reactions produce heavier elements. We are made of these heavier elements — “star stuff” as Carl Sagan famously noted. But the precise recipes for star stuff are a bit of a mystery, since we can’t exactly send a probe into the interior of a star to observe reactions as they occur.

At the Fall 2022 Meeting of the APS Division of Nuclear Physics in Spokane, Washington, experts gathered to discuss in detail how heavier elements are created in stars. Some researchers focused on the strange abundance of a specific stellar ingredient familiar to terrestrial recipes: sodium.

Salty Stars continued on page 5

A globular cluster of stars called 47 Tucanae. In some clusters, scientists have observed almost 100 times more sodium than exists in our solar system.

Credit: ESO/M.-R. Cioni/VISTA Magellanic Cloud Survey

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A globular cluster of stars called 47 Tucanae. In some clusters, scientists have observed almost 100 times more sodium than exists in our solar system.

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A globular cluster of stars called 47 Tucanae. In some clusters, scientists have observed almost 100 times more sodium than exists in our solar system.
How Sound Waves Could Power a Greener Air-Conditioner

At an APS meeting on fluid dynamics, researchers discussed thermoacoustic heat pumps, a decades-old technology they believe could emit fewer greenhouse gases than conventional cooling technologies.

BY LIZ BOATMAN

A s global populations grow and the climate wars, humanity will need increasingly effective ways to cool itself off — on an enormous scale. Experts predict that, globally, the number of cooling systems, like air conditioners, could double or even quadruple by 2050. Today’s 3 billion refrigerators and heat pumps are in service, all air conditioners and electric fans consume 20 percent of electricity in buildings. As more of these tech- nologies are used, waste heat, power consumption, and greenhouse gas emissions will grow too.

For a world trying to rein in global warming, this is bad news.

One research team is working on a unique solution known as phase-changing the microwave. A doctoral student Nathan H. Blanc of Technion, the Israel Institute of Technology, says thermoacoustic cooling has big advantages over conven- tional air conditioning. “With a longer technology lifetime, it’s much more sustainable,” he says. Blanc presented recently published research at the 2023 APS Division of Fluid Dynamics (DFD) meeting in Indianapolis, Indiana, in November.

Blanc’s co-authors are Guy J. Ramon, his advisor at Technion, and Ramon’s former postdoc, Rui Yang — the first author on their recent study, published in Energy Convers- ion and Management. Now, Yang is developing a research program at the Technical Institute of Physics and Chemistry in Beijing.

Despite new interest in thermoacoustic cooling, the technology itself was pioneered in the 1980s. Greg Swift, a now-retired researcher, started his career at Los Alamos National Laboratory as a postdoc working on alternative energy. At one point, his mentor left town on a trip — and came back with an idea. “We started out with simple experi- mental tests of the most basic thermoacoustic math,” he says, and the field was born.

How does thermoacoustic cool- ing work? First, an inert gas is sealed inside a tube that’s lined with heat-exchanging materials. When an alternating sound wave is fed into the tube, in low-pressure areas of the wave, the gas expands and absorbs heat; in high-pressure areas, the gas is compressed and expels the heat. Controlling the sound wave controls where heat is absorbed and released.

Although a wave only moves each bit of gas a short distance, the cumulative effect amounts to a “bucket brigade,” creating a relatively cool-pumping system with few or no moving mechanical parts, Blanc said at the DFD meeting. This re- duces the chance that the system breaks and lengths its lifetime.

In fact, the technology is so reducible that a variation of it was recently launched into space aboard NASA’s James Webb Space Telescope to cool its mid-infrared light spec- trograph instrument. “You would only need a technology to space where no one is there to fix it, that you can count on,” says Blanc.

Despite the historical contri- butions that scientists in the U.S. made to the field, if you search the phrase “thermoacoustic cooling” on Google Scholar, you’ll find few recent contributions from U.S. researchers.

“Our flagship attempt to do something practical [with the technol- ogy] was a combination-powered generator, and another of nature’s gas,” says Swift. “We worked out the physics, made great progress on the en-... Cooling continued on page 4

The history of particle phys- ics is littered with spurious findings, blips in the detector that disappeared on second inspection. Most of these false discoveries have been buried under the deluge of real discoveries. But the “ Oops-Leon,” which would have been a new par- ticle with a mass of 6 giga-electron- volts (GeV), remains unusually vivid.

During the late 1960s, the cohort of elementary particles was small but growing. Physicists had already discovered three types of leptons — electrons, muons, and neutrinos — and three of quarks — up, down, and strange. But the quarks were still just mathematical entities, not yet spotted in experiments, and the three remaining quark flavors — charm, top, and bottom — had not yet been proposed.

In 1967, Leon Lederman and his colleagues began a new experiment at Brookhaven National Laboratory, aimed at finding new particles. They slammed 30-GeV protons off an ultra-thin neutron-rich uranium, which would decay first into virtual photons and then into pairs of electrons or mu- ons — which could, in turn, be scruti- nized by sensitive instruments for signs of new physics. To filter out the unwanted collision debris, the researchers used 10 feet of steel from the old World Trade Center, which only muons could pass through.

The team expected to see a smoothly falling distribu- tion of muon pairs and knew any coup could signal a new particle. But when Lederman saw a faint bump at 3 GeV, they convinced themselves it was nothing. “The signal was intrinsically there,” says Dana Kaplan, an emeritus pro- fessor at the Illinois Institute of Technology who worked with Led- man later, “but they would have had great difficulty publishing this dis-... Oops-Leon continued on page 4

The E288 team began to see a distinct bump around 3 GeV, suggesting the predicted background was four. The team calculated there was a 2 percent chance a signal that large would result from a statistical fluc- tuation alone. The team, it seemed, had stumbled on a brand-new parti- cle, and it needed a name.

Chuck Brown, a member of the E288 team noted from Fermi- lab, recalls a late-night shift with Jeff Weiss, poring over available Greek letters. “Iota was rejected since it resembles a question-mark — in hindsight, it would have been a better choice,” John Yoh, the experi- ment’s coordinator, wrote in 1997.

Then Walter Linn suggested that, if a particle named “Ipsilon” turned out to be a mirage, they could simply call it an “Oops-Leon.”

Incidentally, another Fermilab group also found evidence for a res- onance at about 6 GeV using a differ- ent method and submitted their findings two days beforehand. Curi- ously, their result has been largely forgotten.

But data quickly cast doubt on both results. A few months later, the E288 researchers included the effect of trials factors, and the 3-GeV signal disappeared. The E288 experiment with muons and found no evidence of excess at 6 GeV and an examination in 1977 finally ruled it out. The Upsilon was an Oops-Leon after all.

What went wrong? A decade earli- er, Philip Wolfe, a physicist at Fermilab, pointed out that “trials factors” — essentially, running an experiment multiple times — would lead to statistically signif- icant “discoveries” that were flukes. To combat this, Rosenfeld proposed waiting until results met a strict sta- tistical standard known as “five-sigma.” But the standard was not adopt- ed in earnest until the discovery of the top quark in 1995, argues experi- mentologist Tommaso Dorigo.

Although the E288 researchers included the effect of trials factors, the 3-GeV peak was still visible. The 3-GeV signal disappeared on second inspection. Curi- ously, the Upsilon was an Oops-Leon after all.

Was people searching around the unknown,” says Chuck Brown, a member of the E288 team. “It’s, in some sense, just luck that we stumbled on [this particle].”
Researchers rework traditional thermodynamics to study mechanisms that create motion from changes in humidity.

By BAILEY BEDFORD

What do pinecone scales and steam engines have in common? They both do work — and both can be analyzed using thermodynamics.

Steam engines and other heat engines, which are powered by temperature changes of a fluid, have been extensively studied and applied since the field of thermodynamics was founded in the 1800s. Now, researchers are exploring alternative methods of generating work, including mechanisms that mimic pinecone scales, which open and close in response to humidity.

In a paper published October 26 in Physical Review Applied, researchers describe new thermodynamical models of engines driven by humidity changes. Their work adapts traditional thermodynamic concepts, developing technology and applies the results to natural and artificial materials.

“Surprisingly, natural systems had a very high efficiency compared to artificial systems,” in their analysis, says Ho-Yong Kim, a mechanical engineering professor at Seoul National University and co-author of the paper. “Enginees that produce motion from a material’s response to a humidity change are an example of technologies called soft engines. Soft engines can be driven by a material’s response to other things, like changes in light, and can be parts of soft robots that fold rigid parts, batteries, and combustion. These traits make soft robots promising for many uses, including in medical settings where batteries or hard edges might injure patients.”

“I think this paper is very important for this field,” says Zhu Lianghong, an engineering professor at Northwest University in Xi’an, China, who was not involved with the paper. He says that the thermodynamics and energy efficiency of soft machines are important for practical applications but rarely researched.

Kim says he was inspired to research humidity-driven soft robots by plants’ motion, and that he was surprised to find a principle that governs both heat engines and soft engines.

Kim and colleagues followed in the footsteps of Sadi Carnot, a French engineer who studied steam engines in the 1800s. Carnot conceived of the cycle that describes an ideal, maximally efficient heat engine. The cycle describes a fluid (usually a gas) that changes temperature, volume, and pressure in four stages, producing work as it shifts between two temperature extremes. The researchers adapted Carnot’s cycle into their own, designing instead a material moving between two levels of humidity.

The team carefully accounted for all the energy changes of a soft engine going through four steps: Ambient humidity increases, the material absorbs humidity and grows, ambient humidity decreases, and the material releases humidity and shrinks.

New Models Expand Thermodynamics to Humidity-Driven Engines That Mimic Plants

Researchers rework traditional thermodynamics to study mechanisms that create motion from changes in humidity.

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APS Innovation Fund Fuels Quantum Education

Online communities help smaller undergraduate schools teach cutting-edge quantum science.

By KATHY JAYN

The emerging field of quantum information science has far-reaching potential applications, from uncrackable encryptions, sensors that enable location tracking without satellites, computers with unprecedented processing power, and national security. As much of the field is still theoretical, technology companies and national laboratories are investing heavily in its development.

“I think we’re approaching a tipping point,” said Justin Perron, an associate professor of physics at California State University, San Marcos. “There’s going to be a case where it’s financially beneficial to use these technologies.”

Perron wants his students to get in on the ground floor of the discipline. But unlike large research universities, California State University mainly serves undergraduates, and the San Marcos campus only has a few faculty members with a background in quantum mechanics: physics professor Charles De Leon and math professor Shabab Sharif.

When the three began meeting to discuss how to teach quantum information science, the challenge they faced seemed stark: In such a highly interdisciplinary field, having a small faculty put Perron and his colleagues at a disadvantage. “We realized it was really hard,” Perron said.

To build a new curriculum, he and his colleagues decided to look beyond the boundaries of their campus.

In June 2023, with the help of an APS Innovation Fund grant of about $82,000, Perron and his collaborators created a workshop called the Quantum Undergraduate Education and Scientific Training (QUEST), geared toward faculty of primarily undergraduate institutions. During the two-day workshop, nearly 100 participants from more than 60 undergraduate institutions met to discuss the challenges and opportunities of quantum information science education.

Perron found that instructors at other smaller colleges and universities were facing similar struggles to expand their programs. But bringing together quantum physicists, computer scientists, engineers, and other specialists made the conference a “brain trust,” Perron said. Together, participants tackled common challenges and shared developing courses, integrating departments, and persuading administrators to offer new programs. During one panel, leaders from Google, the University of Colorado, Boulder, and consulting firm Bexx Allen

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Science Policy Successes in 2022

APS members worked tirelessly for this year’s achievements.

BY TAWANDA W. JOHNSON

Dedicated volunteers helped APS accomplish its 2022 science policy goals, which included supporting legislation to strengthen U.S. science and technology innovation, combat climate change, and raise immigration for international scientists. Volunteers made more than 4,700 connections with Congress, including phone calls and emails.

“We’re proud of APS members’ hard work,” said Mark Elesser, director of government affairs for APS. APS’s 2022 science policy successes are highlighted below.

CHIPS and Science Act

The CHIPS and Science Act of 2022, signed into law on Aug. 9, is the most important bill for science and technology in more than a decade. APS and its members were strong advocates for the bill. The legislation significantly increased authorized funding to federal science agencies and included provisions that APS has pushed for years to advance: creating a stronger and more diverse workforce, combating sexual and gender harassment in STEM, and addressing the helium crisis through increased recycling efforts.

China Initiative

APS was a leading voice in helping to end the China Initiative, a program intended to crack down on illicit acquisition of U.S.-based scientific knowledge or technical expertise, as well as the illicit acquisition of U.S.-based scientific equipment or materials.

“People were searching around in the bush for something to prove a point,” said D. Niko London, professor of physics at Adelphi University, who was involved in the research. “It’s like many of the California State University system, ‘tend to have much more diverse populations,’” Shaff said. In 2021, 51 percent of CSU undergraduates were Black or Latinx, compared to 29 percent of University of California undergraduates.

In the academic year following the workshops, 16 participants met in four online communities to develop curricula for quantum information science at their institutions. Some created summer courses to introduce undergraduates to the field, while others began building long-term plans to create whole courses or major concentrations.

For Sean Bentley, an associate professor of physics at Adelphi University who is developing a quantum and the material releases humidity and shrinks to its initial state. The researchers identify the most produc- tive efficiency of a humidity-driven soft engine, which depends on the temperature and humidity of the environment.

But a soft engine that faces no resistance isn’t very practical, so the team adapted their model to account for the material pushing on something as it expands, which they call diffusion. They adapted the cycle for a type of soft engine that bends, using a mechanism similar to that in pinecone scales. This further decreases efficiency but allows for greater movement over a larger distance.

The researchers’ results indicate that, for a bending soft engine, a thinner absorbent layer tends to be more efficient but also produces less mechanical work. So, the team proposes using an alternative value, called the work ratio, to evaluate the performance of a soft material in engines that bend. The value reflects the propor- tion of a soft material’s hypothetical energy that is extracted by the bending mechanism — so the higher the value, the more efficient the engine is getting work from its soft material.

Using existing literature, the researchers calculated the work ratio of several engines based on various humidity-absorbing natural and artificial materials. They found that the work ratios for the engines using natural materials tend to range from 0.2% to 2%, while almost all the artificial soft engines didn’t use plant-based materials and had work ratios below 0.1%. The analysis suggests plant-based bending soft engines are generally more than twice as good as purely artificial counterparts at harnessing the potential work of their humidity-absorbing material.

“Plants are very, very clever crea- tures in making motions without muscles,” Kim says. “We have to learn from plants.”

The team suggests that the higher efficiency of natural materials is likely related to the pace of plants’ mechanisms, which generally oper- ate more slowly than those of their artificial counterparts.

Looking forward, the team says their models potentially could be adapted to soft engines driven by the diffusion of other stimuli, like sol- vents, heat, or ions. Kim says their models provide a more guided way to develop materials for soft engines than trial and error.

“I’m not saying that this meth- odology should be adopted by every soft material scientist, but I’m just suggesting that you have to look at the energy efficiency of those soft materials,” Kim says. “This is one methodology you can adopt.”

Bailey Bedford is a science journalist based in the Washington, D.C. area.
Salty Stars continued from page 1

Though we can’t peer inside stars to watch the cooking process, we can identify their elemental ingredi ents — data that the stars give off. Sodium has been found to have a variety of effects on stars, from changing their color to affecting their lifecycle. And in globular clusters, which are massive spherical conglomerations of up to millions of stars, scientists have observed almost 100 times more sodium than is present in today’s universe.

“Sodium is very easy to destroy. The star should have no problem destroying it,” said Richard Longland, associate professor at North Carolina State University and researcher on the project. (No nuclear physicists, “destroy” means “change into another element.”) “But there’s a surprisingly large amount of sodium in these stars, so there must be something about the stellar environment that is keeping sodium from being absorbed into other reactions.”

But unlike the mystery of sodium’s abundance, scientists have also observed an anti-correlation between sodium and oxygen in stars. As there is more sodium there is, the less oxygen there is. But recipes that produce or destroy sodium tend to produce or destroy oxygen, and vice versa.

So the question becomes two-fold: why is there so much sodium in globular clusters, and why is it correlated to the amount of oxygen?

“The problem is that we don’t know” said Longland. “You can’t see by looking at the outside of the star what the conditions on the inside of the star are, and that’s why there’s still a lot to discover. But this work can help us start ruling things out.”

In the sodium-destructing reaction studied in this case, sodium absorbs a proton and turns into magnesium. Considering that stars are mostly made of protons, this would be an easy recipe to execute in a stellar oven. Raisin Song, a graduate student at the University of Texas at San Antonio (UTSA), she realized that, to make that dream a reality, she’d have to hood herself. Vega had dreamed of working at NASA since she was a child. In college, she was a member of the Stellar Flares team, in the Exoplanets and Stellar Astrophysics Laboratory, she studies the ultraviolet light from M-type red dwarfs.

In her last semester, Vega attended a 2013 conference organized by Americans in Science. There, she heard a talk by an APS graduate student who presented a paper in which they found a large amount of sodium in stars. “I reached out to my Astronomy 101 professor, Eric Schlegel, asking if he had any opportunities,” she says. “He was open to anything.” She was in love. Over the next several years, Vega helped collect data from two NASA telescopes. The projects put her on the fast track to NASA.

In her last semester, Vega attended a 2013 conference organized by the Society for the Advancement of Chicanos/Hispanics and Native Americans in Science. There, she met David Ernst and Rodolfo Montez Jr., from Vanderbilt University, who told Vega about the Fisk-Vanderbilt Master’s-to-PhD Bridge Program, an APS Bridge Program partnership. The program, which helps students earn master’s degrees at Vanderbilt University and then doctoral degrees from Vanderbilt, has become a model for supporting students from underrepresented minority groups as they pursue advanced degrees in physics.

“This felt like a fusion of the [Fisk-Vanderbilt Bridge program],” she says. “I was like, this is what grad school is supposed to be.”

So after earning her physics bachelor’s degree in 2013 from UTSA, a Hispanic-Serving Institution, Vega moved to Nashville, Tennessee, to start her master’s degree at Fisk, a historically African American institution.

“That was what I wanted — my heart was set on it,” she says. “But I was also worried about moving from San Antonio. I had lived with my parents all my life.”

At Fisk, Vega researched a class of pulsating supergiant stars known as RV Tauri variables, including a star called DF Cygni. Discovered in 1926 by astronomer Margaret Harwood, DF Cygni was the only RV Tauri star in the original field of view of NASA’s Kepler space telescope. The Kepler mission was NASA’s first intensive effort to find Earth-sized and smaller planets in the habitable zones of stars like our Sun.

The telescope monitored more than 300,000 stars, including DF Cygni, to record their brightness over time — data which Vega used to complete her master’s thesis. DF Cygni is still Vega’s favorite star, because of its connection to the pioneering work of astronomers like Harwood.

In 2017, after completing her master’s degree and publishing her first paper in The Astronomical Journal, Vega enrolled in Vanderbilt’s astrophysics doctoral program. As the Fisk-Vanderbilt Bridge Program student, Vega crafted a new project focused on U Monocerotis, a different RV Tauri star. U Monocerotis is the second brightest RV Tauri in the Milky Way, which only has about 300 of the pulsating stars. The star is actually a binary pair, and the larger of the two stars has twice the Sun’s mass but 100 times its size.

When Vega faced a setback — she failed her first attempt at her qualifying exam — she knew that she’d have to huddle up with her friends’ support. “When you talk to your close friends or peers who are also in graduate school with you,” she says, “you realize ‘we’re all in this together.’”

Vega took the qualifying exam again and passed. “I felt relieved,” she says, “but at the same time, I was still wondering, was it real?”

In 2021, Vega’s research on U Monocerotis was published, and NASA featured an article on her work. A few months later, Vega walked across the stage to collect her diploma. Because of the pandemic, Vega’s advisor, Retwan Stassun, was not allowed to place her hood, an important tradition to many graduates.

But that night, when Stassun joined Vega’s family for a dinner celebration, he was able to place Vega’s hood around her neck. She was certain — it was real.

While Vega is a year into her postdoc at NASA-Goddard, she’s investigating the effects of red dwarf ultraviolet flare activity on planet atmospheres, and it’s not easy work.

“We have a large data set of simultaneous observations across many different telescopes,” she says. “All the observations must be carefully analyzed.”

What’s next for Vega? “I hope to keep on being a scientist at NASA,” she says. “I’ll have to work hard to do that, but I have the motivation.”
A paradigm shift is occurring in our society. Somewhat, unbeknownst to many, knowledge and opinion are increasingly confused. As scientists, we know that facts are facts, no matter how bad actors spin them, and that scientific consensus is generated by a rigorous process based on evidence and experimentation. But denial of climate change, vaccine hesitancy, anxiety over nuclear energy, fears of GMOs, and even mistrust of individual scientists (e.g., Anthony Fauci) are rampant online and in everyday conversation. This misinformation bewilders the public, leads to policies that hurt people and the planet, and poses risks to science itself. Will science lose its ability to shape the future?

To reverse this dangerous direction, we scientists must go straight to the public. “Public engagement” is any effort to work with and inspire non-experts, and it takes many forms. A scientist might visit a classroom, speak on a podcast, invite the public to tour a lab, help design a museum exhibit, give or attend a public lecture, or work with journalists on a science story.

Beyond this, though, public engagement should be an expected skill of our profession. It should be recognized by our institutions and used, along with research, teaching, and service work, in hiring and promotion decisions (as we discuss below, this is seldom the case today). This no-cost change at institutions would boost participation in engagement activities that can build back public trust in science and help our field.

Engagement work is needed because it gives science a human face, a proven way to build comfort and trust. And direct, person-to-person engagement can do more than simply provide information: By personifying a topic, we make it relatable. For example, instead of debating the specifics of climate change, we can shift the discussion to the plight of those who have lost homes to fires in the western U.S.

And by discussing people’s fears and misconceptions, engagement can go beyond trust-building. It can change the minds of people skeptical of science. The benefits of personal interactions with the public, which can surpass the benefits of reading an article or hearing a lecture, have been documented across a range of topics, including ocean pollution, vaccines, drug treatments, nuclear energy, and environmental disasters.

Unfortunately, we scientists face a dilemma each time we are offered a chance to engage with the public. We must choose between that effort or work that advances our careers. Public engagement is often evaluated indifferently or negatively during hiring, performance assessments, and promotion decisions, despite its importance for the future of our field. If you’re doing outreach, so the thinking goes, you’re not doing the important stuff.

This attitude throttles participation in engagement work. That’s why we urge academic institutions — like universities, national laboratories, and research facilities — to change their policies and make participation in public engagement a criterion for hiring and career advancement decisions.

We envision public engagement as an addition to, rather than a replacement for, traditional hiring and promotion requirements. We also believe that these skills should be developed at all stages of a scientist’s career, beginning with the undergraduate curriculum and expected of graduate students, postdocs, and faculty.

While the scientific community already has (albeit imperfect) ways of evaluating research, teaching, and administration, it has given little thought to evaluating public engagement. However, we recently suggested criteria that institutions could use to evaluate this work. This will take commitment from all of us, and below we describe resources that can help. We also hope to get help from APS. At the time of writing, the APS Panel on Public Affairs is considering a draft statement that supports public engagement efforts and recommends that institutions consider such work in hiring and career advancement decisions.

We realize, however, that the change is hard, and that the academic world is particularly slow to reform. You need only look at the gate we wear at graduations to realize that universities value tradition. In our own field, the phrase “modern physics” describes century-old discoveries. For institutions to make a substantial change, it must be in the institution’s interest.

Fortunately, effective public engagement has enormous benefits. Spreading the word about research successes can bolster an institution’s reputation, a key to landing external funding. Events like science cafés, lab tours, or school visits can forge strong ties to the local community. And by working with journalists, you can share your science with non-experts and help build public support for your next exciting, and perhaps taxpayer-funded, project.

Well-designed engagement events can also help build a physics identity for both facilitators and attendees — in other words, help them imagine themselves as physicists, with their own unique style. This has been shown to attract people to, and keep them in, physics. To achieve to best practices, the designers of these programs should collaborate with skilled facilitators or physics education experts.

Better still, public engagement can inspire the next generation of scientists, sparking curiosity in ways difficult to replicate in class. One of us, Lincoln, became a scientist in part because he read books by Asimov, Gamow, and Sagan, written for non-experts. In turn, he has met students who went into physics because of books he authored. Now he hopes these budding academics will find a niche.

The other (Smith) vividly remembers the high school science fair where Swift left off. Instead of relying solely on an inert gas for heat transfer, Swift’s team was adding a phase-change fluid. At that stage, according to their professor, it would not have been as efficient as a traditional one, according to their team.

But Blanc’s team isn’t simply picking up where Swift left off. Instead of relying solely on an inert gas for heat transfer, Blanc’s team is adding a phase-change fluid. The phase-change fluid is cycled between its liquid and gas phases to release and absorb heat. So far, the team has experimented with water, ethanol, and isopropanol. Though the phase-change fluid restricts the system’s temperature range, their prototype is twice as powerful as traditional thermoacoustic cooling when heating pump heat between temperature differences of 10°F, according to the team’s most recent data. Calculations suggest that full-scale models could be more powerful, and might even outperform conventional air-conditioning technologies.

“I definitely intrigued,” says Swift. “Getting most of the heat to happen with phase change instead of adiabatic pressure changes in an inert gas might be a game-changer.”

That’s exactly what Blanc, Ramirez, and Yang are hoping for. The efficiency of phase-change provides an opportunity for thermoacoustic cooling to compete with classical technologies, say experts.

Today, the team’s heat pump prototype is powered by grid electricity, but Blanc and his team are working on designing the pump so that its power comes entirely from heat — either solar or waste heat.

The trio has a lot of work to do, but they’re optimistic. “I hope our work will inspire other applications, such as a large-scale application of thermoacoustic cooling into reality,” says Yang.

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