FORUM

RESPONDING TO CHINA

John Deutch's "Is Innovation China's New Great Leap Forward" (*Issues*, Summer 2018) does an excellent job of describing the current status of US-China relationships in the context of innovation-based economic competition and, to a certain extent, national security issues facing both countries. He makes the traditional arguments that the United States needs to tighten (not close) its science and technology (S&T) infrastructure, maintain its tech-based entrepreneurial and new venture edge, and continue investing in university-based science, engineering, and advanced education. Basically, run faster. A perfectly reasonable conclusion to reach, but for a material error of omission in his assessment of the current relative strengths of the innovation paths of the two countries.

As he concludes his problem assessment, he writes: "The record clearly establishes extensive illicit technology transfer behavior.... What is striking is the implied judgment that this illicit behavior has been and will continue to be decisive to the advance of Chinese innovative capability. There are few, if any, voices raised to say that significant improvement in Chinese innovation should be expected with the growth of China's economy and the increased maturity of its indigenous science and technology infrastructure *without* any illicit behavior." This strikes me as important and well-articulated, but incomplete.

When considering US innovation-based economic performance, the relevant reference point is not just Chinese performance but also the performance in the rest of world (ROW) beyond the United States. Significant improvement in ROW innovation should be expected with the growth of the ROW economy and the increased maturity of ROW indigenous S&T infrastructure without any illicit behavior.

Since the end of World War II, the United States has led the world in R&D investment and in university-based S&T education. That means, with some inevitable waste and slippage, that it has led the world in innovation. However, the pack of other nations in this race—the United Kingdom, Germany, South Korea, Japan, France, and now China, among others—has substantially closed the gap. The United States is still in the lead but, more than ever, running as part of the pack rather than far out ahead. It is important to recognize that the United States has benefited directly from the gap being closed. It now shares the burden of scientific advance for global civic missions—public health, education, environmental quality—and it benefits directly and economically from scientific and technological advances pioneered elsewhere. In other words, in the twenty-first century, national innovation systems have bled together into a single global innovation system.

In this global system of innovation China stands out for three reasons: the size of its economy; the pace of its economic and innovative growth; and the fact that it is not playing by the rules—explicit and implicit—that govern the other leading countries in the race. So, Deutch's "tighten but don't close" and "run faster" conclusions are good as far they go, but they need to be recast for a multilateral S&T world where neither bilateral trade agreements nor World Trade Organization provisions provide adequate rules (or enforcement) to ensure R&D reciprocity and fair technology transfer, or to govern tech-related foreign direct investment.

This leads down a less traditional path that includes a number of policy innovations:

- Technology-driven industrial policy that allows the United States to lead the pack where it is important for the US economy or national security.
- Revisions to economic and technology policies to increase focus on the US capture of economic benefit from increasing investments in innovation infrastructure around the world (which may require revisions to antitrust policy, patterns of domestic S&T investment, or incentives for US foreign direct investment.
- Substantial revision to, and better US systems to manage and enforce, multilateral agreements and norms (i.e., tighten but not close the US innovation system) in the context of the global innovation system.

There is a great deal of policy work to be done on each of these fronts.

Bruce Guile
Senior Fellow
Berkeley-Cambridge Innovation
Infrastructure Initiative
Haas School of Business
University of California, Berkeley

CAREER DEVELOPMENT IN GRADUATE EDUCATION

In "Critical Steps Toward Modernizing Graduate STEM Education" (*Issues*, Winter 2019), Alan Leshner and Layne Scherer note that career exploration and professional skills development should be core components of an "ideal" graduate program . Indeed, individual mentoring can be highly variable, making access to structured professional development programs an issue intricately linked to equity, inclusion, and retention of early career scientists.

In recent years, many graduate

Continued on page 7 →

PHILLIP K. SMITH III *Lucid Stead* is the homesteader shack in Joshua Tree, CA

From Lucid Stead
Prints and Works by Phillip K. Smith III

The exhibition *From Lucid Stead: Prints and Works by Phillip K. Smith III* is on view at the National Academy of Sciences in Washington, DC, from March 18 through September 13, 2019. It is inspired by *Lucid Stead*, Smith's 2013 installation in Joshua Tree, CA. To create *Lucid Stead*, he transformed an existing homesteader shack into a mirrored structure that, by day, reflected the desert surroundings (as seen in the photograph) and, by night, shifted into a color-changing projected light installation.

Smith creates large-scale temporary installations drawing on concepts of space, form, light, shadow, environment, and change. His practice is informed by his architecture training at Rhode Island School of Design. His works include *The Circle of Land and Sky* (2017) at the inaugural *Desert X* in the Sonoran desert, *Open Sky* (2018), in Milan's 16th-century Palazzo Isimbardi, and *Detroit Skybridge* (2018), commissioned as part of Detroit's Library Street Collective's revitalization effort. Producing extraordinary and communal encounters via installations that explore the transitory nature of light, Smith fosters inexpressibly human, immaterial, and unifying experiences that elude language and defy form, but can be undeniably felt.

Through his pacing of color, reflection, and use of the environment as material, Smith encourages us to slow down and observe our surroundings in new ways.

PHILLIP K. SMITH III *Lucid Stead Elements #1*, 2017, 47 x 8.75 x 6 inches

Brushed anodized aluminum, glass, acrylic, wood, *Lucid Stead* original siding, LED lighting, electrical components, *Lucid Stead* color program. Collection of Rodney D. Lubeznik and Susan D. Goodman.

This sculpture is composed of the *Lucid Stead* installation's raw elements—the original wood siding, the mirror, the white light, the 2x4 structure, and the shifting color—contained within a crisp aluminum frame.

PHILLIP K. SMITH III *Lucid Stead*, 2013, Joshua Tree, CA

Its color scheme is inspired by the color-changing light projected onto *Lucid Stead* at night (as seen in the photograph above).

Continued from page 5

schools have invested in the creation or expansion of PhD-specific career and professional development programs, attributable in part to funding agencies' higher expectations for training grants and funding for innovation in this area. Though promising, access to professional development programs is not sufficient. Whether real or perceived, pressures for research productivity create barriers to attending workshops or exploring careers. Indeed, student attendance and faculty buy-in are two of the four top challenges facing professional development programs, according to a 2018 survey by the Graduate Career Consortium. These challenges speak to the systemic barriers that must be overcome for programmatic investments to have impact.

Six years ago, the University of Massachusetts Medical School proposed a fundamentally different approach: to reframe career development as an expectation for all PhDs by building career and professional development directly into and across the required curriculum, rather than considering them extracurricular. Each educational component is tailored for students' specific year in training, and requires minimal time commitment—important for faculty buy-in. As a next phase, we will be developing evidence-based mentoring resources to maximize synergies between the curriculum and individual mentoring practices.

Funded by a National Institutes of Health BEST award, we are assessing outcomes and impacts of these curricular changes, including attitudes and behaviors of students and faculty. We are fortunate; rigorous program evaluation is difficult and resource-intensive. With few incentives and resources for evaluation, the field of graduate education is significantly less developed than undergraduate education.

To advance graduate education—including career and professional development—the field needs to move toward scientific teaching and consider ways we can better disseminate (and support adoption of) best practices, so that efficient change can happen at a systems-wide, national level. Though multiple organizations have created national communities that actively exchange ideas, much innovation continues to take place within silos. As recommended by Leshner and Scherer—as well as by Ronald J. Daniels and Lida A. Beninson in their article, "Securing the Future of the US Biomedical Research Workforce," in the same volume—there would be great value in working together and across stakeholders to enhance research, innovation, and dissemination in graduate education.

I am working on two multi-stakeholder national initiatives to address these goals. Through one, I3IDP, we are developing toolkits to help universities assess their Individual Development Plan processes. The second is a broader initiative to create a national center to incentivize and support the spread of evidence-based practices in career and professional development by building capacity for

stakeholder collaboration, dissemination, high-fidelity implementation, and evaluation.

As part of national efforts to build an inclusive and equitable training environment, we must reframe career and professional development as a core part of STEM training, as integral as understanding basic genetics principles is to becoming a geneticist. Building national capacity for testing and disseminating educational innovations will accelerate advancement of graduate education practices. As STEM PhD career trajectories continue to evolve, our ability to adapt educational practices will be essential for continuing to attract talented prospective students to PhD training, and ultimately for the health of the scientific enterprise.

Cynthia N. Fuhrmann
Assistant Dean, Career & Professional Development
Associate Professor, Biochemistry & Molecular Pharmacology
Graduate School of Biomedical Sciences
University of Massachusetts Medical School

As a group of current and recent STEM graduate students, we applaud Alan Leshner and Layne Scherer's argument for systemic changes that are essential to improving graduate education. Many of their points deeply resonate with our perspectives, especially the lack of support for students and preparation for jobs outside academia. As this article ironically notes, "Over 20 studies and reports on graduate (STEM) education have come to that same conclusion," while research institutions continue to struggle to create sustained change.

Increasing numbers of PhDs are pursuing nonacademic careers rather than tenure-track faculty positions, but we believe that framing these changes as an effort to "modernize" is problematic. It allows the established academic community to avoid responsibility for and reflection on the institutionalized flaws in graduate student training. Graduate STEM education systems have always had an obligation to be ethical, empathetic, and all-around mindful of the needs and goals of the students, contrary to the implications that this is a contemporary challenge.

Indeed, "real change requires a systems approach," as their article notes, but all levels of the academic ecosystem are not equal in their power and influence. Students have a responsibility to pursue interdisciplinary training and professional development, and faculty have a responsibility to be inclusive and supportive resources for their students. But we believe that the critical role of university administrations and deans is being dangerously overlooked. Leshner and Scherer acknowledge the fact that systematic change is inherently difficult in decentralized systems, which further highlights the importance of holding institutional leadership to a higher standard, since they reflect a small number of individuals with immense local power. The recommendations in the recent National Academies report on which the authors based much of their article should be prioritized and integrated into top-down university hiring requirements, strategic planning, and budget allocations in order to lead by example and shape campus culture to be conducive to change-making at the faculty, staff, and student levels.

Furthermore, a call for changes in funding criteria from state and federal agencies is not sufficient to produce more than superficial results. Successful systematic change will also require putting the spotlight on institutional leaders, challenging them to think creatively and holding them accountable on their promises to prioritize graduate student success.

It is especially important that all levels of leadership within academic institutions support the bottom-up grassroots efforts of graduate students. In the absence of institutional support, these student-led efforts are providing hands-on experience, community building, and public outreach that fill the gap in professional development opportunities. For example, the National Science Policy Network is comprised of early-career scientists and engineers across the United States who are pursuing focused training and professional development opportunities that align with science policy and advocacy career goals. Unsurprisingly, the majority of these efforts operate on shoestring budgets or even on the sheer willpower of student volunteers. In response to the National Academies report, we hope that more university faculty and administrators will step up as allies and advocates who can facilitate the prosperity of graduate student- and postdoc-led endeavors.

Ultimately, early-career researchers who don't feel welcome or supported in academia because of their extracurricular efforts aren't going to stay around to eventually become tenured committee members and advocate for this vision of reformed STEM graduate education. Instead, they will leave, and myopic attitudes toward graduate education will continue to proliferate within the walls of academia. However, the pursuit of healthier and more equitable academic environments; higher-quality of teaching, advising, and mentoring; and expanded support for more interdisciplinary curriculum and research has the potential to benefit not only individual students but also the broader standing of science in society.

Holly Mayton
Michaela Rikard
Avital Percher

ENGINEERING EDUCATION REINVENTED

Richard K. Miller begins his article, "Lessons From the Olin College Experiment" (*Issues*, Winter 2019), by stating that "higher education is notoriously hard to change." This statement is accurate, as this desired change presents challenges, but it is also

PHILLIP K. SMITH III, *Lucid Stead: Focused Views - View 6*, 2013-2019; Archival pigment print, 47 x 8.75 x 6 inches

Lucid Stead: Focused Views

Phillip K. Smith III took this series of photographs in 2013 prior to closing the *Lucid Stead* installation. The photographs are detailed and cropped views of the homestead shack, drawing attention to the relationship between the weather-worn wood, reflection, and the environment.

The day after Smith took these photographs, he decommissioned the work by returning the cabin to its original state with one exception: He did not reattach the original wood siding he had removed, but rather kept it catalogued in his studio. These woods slats would become the originators of the *Lucid Stead Elements* sculptures, one of which is also featured in the exhibition at the National Academy of Sciences.

an opportunity. Based on the successful 20-year history of engineering education innovation at Olin College, Miller, who is president of the college, offers five lessons learned during the creation from scratch of the educational experience there, from working with an initial class of 30 "Olin Partners," to a campus-wide commitment to continual innovation, to the challenges experienced once the inertia of success sets in. Indeed, Olin College has rightly enjoyed tremendous success during a short period, creating an identity as a leader and innovator in undergraduate engineering education.

How do these ideas for education innovation and lessons from Olin College's first 20 years translate to an institution such as the College of Engineering at the University of Illinois at Urbana-Champaign, which is an order of magnitude larger than Olin College and steeped in rich history with an already established strong identity and legacy? Can new pedagogical models take root and flourish at a large research-focused university and college of engineering such as ours? The iFoundry in our College of Engineering was created in 2007 to challenge our traditions and to pilot such models. In the 12 years since its inception, we have learned and confirmed many of the lessons described by Miller. Collaborations between faculty from Illinois Engineering and Olin College have helped solidify the bedrock principle of what is now our Academy for Excellence in Engineering Education (AE3), which offers an additional lesson learned.

That lesson is: communities of practice support faculty-driven innovation. Over the past six years, through our Strategic Instructional Innovations Program (SIIP), 28 teams comprising over 120 faculty have

PHILLIP K. SMITH III, *Lucid Stead: Focused Views - View 4*, 2013-2019; Archival pigment print, 44 x 30.5 inches

led real change in the classroom, including integrating design thinking across curricula, developing a robust online framework for learning and assessment, and enhancing the communication skills of engineering students. A group of Education Innovation Fellows (EIFs), themselves engineering faculty, shepherd the teams in their endeavors. Importantly, these EIFs serve as the connective tissue between different SIIP teams and academic departments, catalyzing communities of practice within the college that support and sustain education innovation. This combination of tight-knit communities working on specific innovations and bridging interactions between teams allows the ideas that work to rapidly spread throughout the college.

Another key component to our success has been taking an engineering approach to education innovation: developing and prototyping educational ideas, measuring the real impact on our students, and then learning whether to pivot or persevere. Our engineering faculty have taken the lead in creating and scaling education innovations by teaching in the same way that we do research—with collaboration, creativity, excitement, measurement, perseverance, and continual improvement. We have found that the broader engineering faculty are more apt to buy in and adopt successful ideas when the innovations are driven by their peers and based on scholarship. By taking this approach, ideas can incubate in more manageable settings before scaling and spreading across curricula to positively impact thousands of Illinois Engineering students each year.

Though "higher education has been notoriously hard to change," change must happen in order for the nation to prepare the future engineers to adapt to the rapidly changing cycles of innovation and to improve the human condition by tackling the grand challenges facing our increasingly connected world. Maintaining disciplinary depth, expanding cross-departmental interdisciplinary breadth, project- and problem-based learning, integrating design-thinking and an entrepreneurial mind-set, and expanding communication skills are all important elements in pursuit of the change. The lessons from the Olin College experiment have brought us many steps closer to realizing this change.

Rashid Bashir
Dean of Engineering and Grainger Distinguished Professor
Laura Hahn
Director of the Academy for Excellence in Engineering Education
Jonathan Makela
Associate Dean of Undergraduate Education
Professor of Electrical and Computer Engineering
University of Illinois at Urbana-Champaign

ADDRESSING SEXUAL HARASSMENT

The article "Treating Sexual Harassment as a Violation of Research Integrity" (*Issues*, Winter 2019) is a necessary read for everyone in all academic institutions. The author, Frazier Benya, was the study director for the recent National Academies report *Sexual Harassment of Women: Climate, Culture, and Consequences in Academic Sciences, Engineering, and Medicine*. Benya and the committee responsible for the report should be commended for an insightful and long-overdue study on a challenging and important topic. I strongly agree with the overarching argument offered by Benya, and in the interest of furthering conversation about harassment in research, I offer some additional issues for consideration, focusing largely on the recommendations she describes in the article.

Benya makes the case that harassment is a violation of research integrity. Though her assertion seems correct, it raises a range of policy and process questions, including how cases should be investigated and who (on an academic campus) would have jurisdiction over such cases. Regarding jurisdiction, Benya rightly notes that various entities on an academic campus have at least some say over research integrity-related matters (e.g., Institutional Review Boards, Institutional Animal Care and Use Committees, Conflict of Interest Committees). Yet following the logic of Benya's argument that harassment in a research setting might be a form of "research misconduct" or "detrimental research practice," the most likely candidate for who would investigate is the entity on a campus that handles research misconduct cases. In practice, this would raise the question of how the process would complement (replace?) the manner in which cases of harassment (including those outside the research setting) are addressed by the campus through its human resources office, Title IX office, or some similar unit. If multiple offices are involved, which one should a researcher who has been harassed report the matter to? Would a researcher potentially have more than one path of recourse against an accused party?

The topic of harassment awareness and prevention should, according to Benya, be integrated into Responsible Conduct of Research (RCR) training. As an instructor of a range of RCR courses, I agree in principle with that notion. However, some challenges need to be overcome. As Benya indicates, many (most?) RCR instructors may not currently have the relevant expertise to cover the topic of harassment prevention. Also, RCR training programs are being asked to cover an increasing number of topics and often do not have the time or resources to do so adequately. In fact, many institutions rely solely on online training to introduce researchers to RCR topics (so what follows is that harassment prevention may become another online training module at many places). In addition, faculty and staff are not normally required to complete RCR training, yet they arguably are the ones most in need of the training considering the power and influence that they have over the next generation of researchers. And as mentioned above, harassment does not occur only in research settings; thus, a case could be made that a campus-wide harassment prevention effort should be considered alongside the focus on the research environment.

A closing thought: Benya's assessment is certainly correct that academic institutions need consistent and effective measures to prevent harassment. It can be hoped that academia will move beyond a time when "research superstars" who are serial harassers are given a free pass because of their prestige and productivity (achieved at the expense of others' well-being). During the time when academic institutions and other entities are in the process of developing educational initiatives and policies related to harassment, they should use it as an opportunity to address other forms of problematic behavior, including bias, discrimination, and/or harassment against individuals due to sexual orientation, religion, race, national origin, or disability.

Jason Borenstein
Director of Graduate Research Ethics Programs
Associate Director of the Center for Ethics and Technology
Georgia Tech

Sexual harassment has been damaging science and research since women began to take their places in laboratories and on research teams over 100 years ago. There is no doubt that sexual harassment hurts science. That it hurts science makes it a research integrity problem. Frazier Benya's call to begin treating sexual harassment as the violation of research integrity that it is provides compelling justification for highlighting this detrimental research practice in responsible conduct of research training. Addressing this issue begins with awareness, articulation, and recognition of its occurrence and harm, which Benya and colleagues thoroughly catalogue in their recent report. Awareness is a start, but minimizing this detrimental research practice requires much more, including moral courage.

Moral courage is defined by the ethicist and author Rushworth Kidder as taking moral action in the face of danger. Doing the right thing even when it has personal or professional costs is difficult for anyone, but is especially challenging when there is a power differential between parties. It is also in situations of power differentials that sexual harassment flourishes. In

many fields of research, where men are overrepresented in leadership and supervisory roles, and where men control opportunities for advancement, the moral courage needed to stop sexual harassment is the moral courage of our male colleagues.

Not unlike any form of bullying, sexual bullying could be greatly diminished if bystanders mustered moral courage and said, "Stop. We do not tolerate sexual harassment in our profession." Female researchers bear the burden of fending off gender harassment and unwanted sexual attention. Many of these very women and their female colleagues also demonstrate extreme moral courage by calling out such behaviors at the cost of their position, tenure, or career. Solving the problem of sexual bullying does not—and should not—lie with the victims of such behavior. The responsibility to end sexual harassment lies squarely with the perpetrators and their male colleagues. Men must demonstrate moral courage, hold their colleagues accountable, and create a respectful climate for all genders.

Adding material on sexual harassment and skill-building for moral action to research integrity curricula is an accessible first step to begin addressing the issue. Doing so requires no change to how we define responsible conduct of research; it requires only will—and moral courage.

We are obligated to address the harm that sexual harassment causes our profession because we are researchers concerned with the integrity of the scientific enterprise. We are obligated to address the harm that sexual harassment causes female scientists because we are human beings concerned with doing what is right. Meeting these obligations requires moral courage.

Lisa M. Lee
Associate Vice President for Scholarly Integrity and Research Compliance
Virginia Tech

UNIVERSITY AS ECONOMIC CATALYST

John Bardo's description of the contributions that Wichita State University (WSU) has made to the innovation ecosystem in its home city, presented in "Innovation in the Heartland" (*Issues*, Winter 2019), provides a compelling example of how public universities contribute to communities. For decades, public universities have played an important role in the prosperity of the United States' heartland by developing the talent necessary to meet the needs of workplaces while providing students rewarding careers; by generating, incubating, applying, and sharing innovative ideas to transform society; and by enhancing the quality of the places they share with their neighbors, students, faculty, and staff.

But they can't do it alone. Universities partner with community organizations; state, local, and federal governments; entrepreneurs, investors, and small businesses; major corporations and philanthropists; and economic development organizations. These efforts focus on a shared vision for healthier and more engaged citizens, thriving economies, and sustainable and resilient communities.

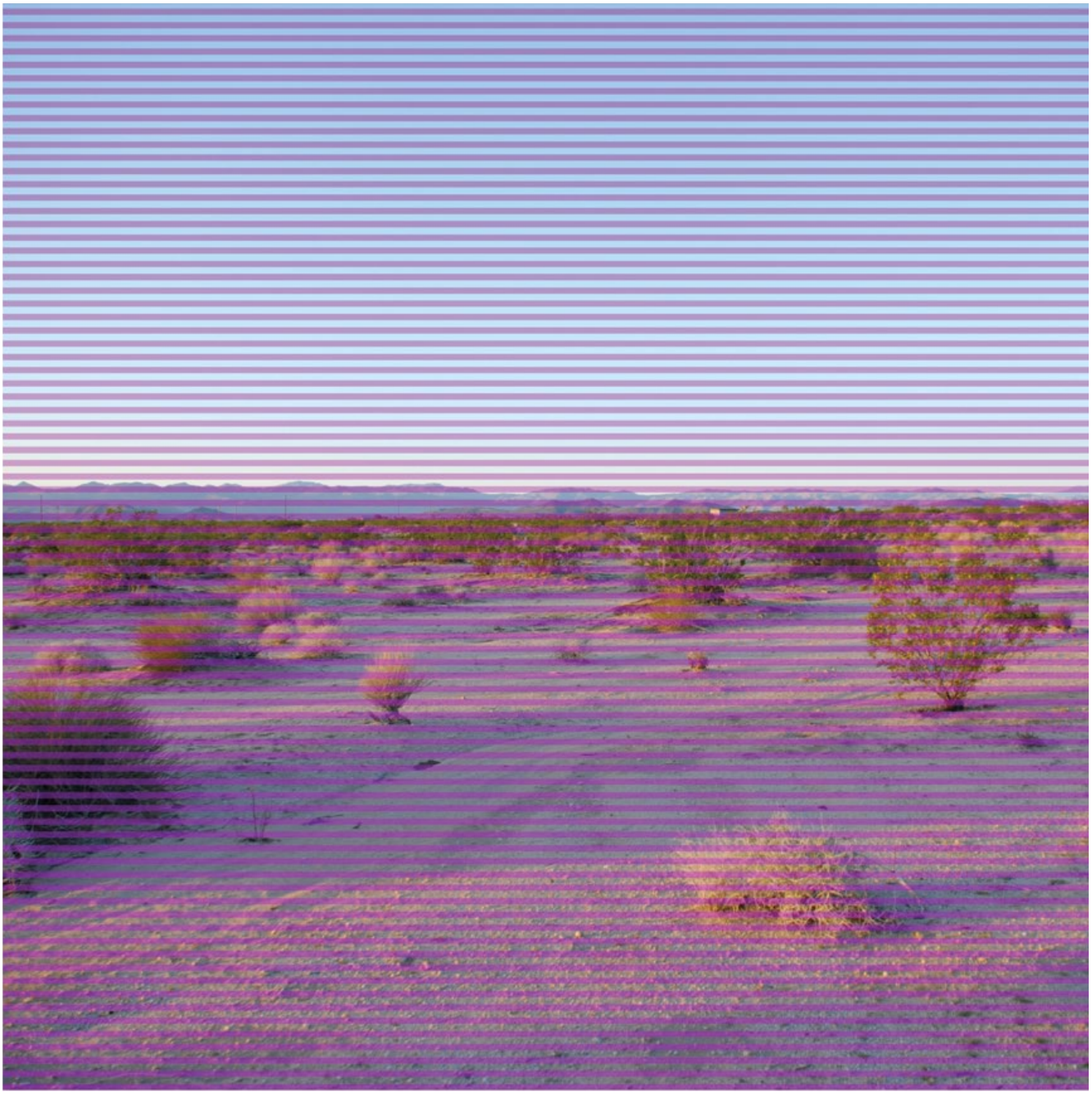
Universities play an important role in developing broader economic strategies. As neutral conveners of community leaders, they provide trusted information, clarify economic and demographic data, explain the implications of technical and economic change, and facilitate agreements among stakeholders that comprise a metropolitan region.

Authenticity drives WSU's vision. Rather than attempting to copy strategies that have worked elsewhere, the leaders developing the university's strategy engaged in a careful assessment of the assets, industries, needs, opportunities, and cultural milieu of the Wichita metropolitan community. As Bardo (the WSU president until his death in March 2019) explained, one size will not fit all. The strategy's authenticity ensures that it makes sense to those who must play a role in its implementation and that the participants share a common understanding of the region.. As Jane Jacobs, the noted activist and writer on urban matters, once put it, "The greatest asset that a city can have is something that's different from every other place."

Bardo noted that the vision for Wichita's future includes focusing on competitiveness in advanced manufacturing, particularly in the aircraft industry, one of the city's economic strengths. To ensure the competitiveness of US manufacturing—in aircraft and other advanced manufacturing industries—the nation must continue to invest in the foundation and advancement of R&D, production knowledge, and manufacturing skills. This requires partnerships among government, universities, and the private sector in basic and applied research and in developing curricula that embed knowledge of advanced manufacturing technology and mastery of the skills required to use it. The results of WSU's partnerships with industry demonstrate how this alignment improves industry competitiveness while ensuring a bright future for their graduates.

WSU's clear commitment to the economic future of its local community is an illustration of the commitment of many public universities. Another example of WSU's dedication is its pursuit to be recognized by the Association of Public and Land-grant Universities as an Innovation and Economic Prosperity (IEP) University. During this process, WSU is engaging with its community to understand its strengths in economic engagement, to measure its engagement, to document its impact, and to tell the story of its contributions to economic and community development.

Continued on page 14 →



PHILLIP K. SMITH III, *Lucid Stead: Chromatic Variants, Violet*, 2013-2019; Archival pigment print, 18 x 18 inches

Lucid Stead: Chromatic Variants

The *Chromatic Variants* series features tight arrays of transparent colored lines that separate and merge an image of the desert with its color-tinted reflection. From a distance, each image of the desert appears as a color-tinted still of the *Lucid Stead* environment caught in a specific moment in time during the shack's changing color spectrum. A closer look reveals the colored bands separating out the view of the desert environment, recalling Smith's use of the surrounding landscape as a medium placed across the banded, mirrored surface of *Lucid Stead*. Smith's choice of six colors echoes the spectrum of colored light used in the four windows and doorway of *Lucid Stead*, while his use of white and black pays homage to the changing of the desert light from the brightness of the day to the black of the night.

WSU's story is only one of dozens of public universities across the heartland that are partnering to build prosperous and resilient communities.

Sheila Martin
Vice President for Economic Development and Community Engagement
Association of Public and Land-grant Universities
Professor of Urban Studies and Planning
Portland State University

DIVERSIFYING THE RESEARCH ENTERPRISE

In "Challenging US Research Universities and Funders to Increase Diversity in the Research Community" (*Issues*, Winter 2019), Freeman A. Hrabowski and Peter H. Henderson implicitly ask, Who will do science at the highest levels in mid-twenty-first America? The answer must be: all of us. Every population group must be prepared to contribute. The nation cannot afford to waste or underutilize the talents of any group.

The authors challenge the top 30 institutions that are the baccalaureate origins for African Americans who earn science and engineering PhDs, and the top 30 institutions that do likewise for Hispanics, to double their production. This is bold, but achievable. One way or another, we will find the resources. For my institution—California State University, Los Angeles—which ranks number 29 on the list, this will be difficult, but doable. We are a Hispanic-serving, predominately undergraduate, research-intensive public institution. We have few research laboratories, directed by a small but active number of faculty who have been exceptionally successful mentoring undergraduates in research. We will be able to increase our on-campus training a bit, but a doubling is unlikely. Yet we may be able to reach our doubling through partnerships with nearby major research institutions that may have additional training capacity, such as the University of Southern California, Caltech, and UCLA, among others. We need to match Cal State LA's student talent with Los Angeles Basin research training opportunities.

When we do reach that doubling, Hrabowski and Henderson will of course expect us to double that number yet again. So, we might as well get working and earn the institutional sweat equity training of all Americans to achieve success in science and engineering. US colleges and universities should see a solid increase in minority enrollments in the near future. Though the nation is a quarter-century from the tipping point where there will be no majority racial or ethnic group overall, the tipping point comes earlier for young people: 2027 for those 18-29 years old, and 2020 (next year!) for those under age 18.

Collectively, there are 60 valuable stories among the 30 top African American producers and the 30 top Hispanic producers of BS/BA alums who earn science and engineering PhDs. The schools span Historically Black Colleges and Universities, Hispanic-Serving Institutions, many research-intensive private universities, and flagship state universities. There are 60 unique circumstances—including an energetic and committed minority president and dedicated faculty in one; another with an exceptionally supportive campus climate and many minority faculty and senior administrators; and yet another with a phenomenal training capacity and mostly majority faculty who have become exceptionally committed to diversifying American science. What do these schools do? How do they do it? Are there common themes, or are they wonderfully idiosyncratic? What can the 2,500 or so colleges and universities beyond the top 30 learn from the top producers? We need to compile these stories as inspirations so everyone can do better. We should not miss the opportunity to document this richness. I am particularly interested in the stories behind MIT; the University of Michigan, Ann Arbor; the University of Florida; Florida State University; and Cornell University. They are on both lists as top trainers of African American and Hispanic PhD-bound talent. Wow!

Carlos G. Gutiérrez
Distinguished Professor of Chemistry, Emeritus
Founding Director, Minority Opportunities in Research Programs
California State University, Los Angeles

Freeman A. Hrabowski and Peter H. Henderson provide a powerful look at the way forward in utilizing America's entire science, technology, engineering, and mathematics (STEM) talent pool. The authors bring into clear focus the continuing underrepresentation of African Americans and Hispanics in STEM fields. Importantly, they offer sound policy recommendations to support evidence-based and promising program strategies to increase the participation of these underrepresented minorities in the STEM workforce.

The authors' tabular data are informative in identifying the top baccalaureate-origin institutions of African American and Hispanic science and engineering doctorate recipients. The data show striking racial/ethnic differences in baccalaureate origins. Most striking is the prominent role played by historically black colleges and universities that are not research-intensive institutions in educating African American STEM students, whereas almost all the Hispanic students are educated at research-intensive universities. This calls attention to the reality that different strategies may be needed to substantially increase the representation of African Americans and Hispanics, respectively.

Moreover, the authors offer the Meyerhoff Scholars Program at the University of Maryland, Baltimore

County (UMBC), a nonminority institution, as an effective, evidenced-based model applicable to various institutions. A significant strength of that program is that evaluation was an integral component in its design and implementation. Unfortunately, far too many programs to increase the representation of racial/ethnic minorities in science and engineering have not undergone rigorous evaluation—especially by a third party. That UMBC's 20-year rise from being unranked to the number two baccalaureate-origin institution of African American science and engineering doctorate recipients is strong evidence that a nonminority institution can accomplish the goals set out in the landmark National Academies report *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads*, which Hrabowski and Henderson cite in their article.

Finally, the essay's opening narrative of the former Meyerhoff Scholars at the NCAA tournament reminds us that in addition to the baccalaureate origins, it is important to know about the careers of underrepresented racial/ethnic minorities.

Willie Pearson Jr.
Professor
School of History and Sociology
Georgia Institute of Technology

NUCLEAR STOCKPILE RELIABILITY

In "The Scientific Foundation for Assessing the Nuclear Performance of Weapons in the US Stockpile Is Eroding" (*Issues*, Winter 2019), John C. Hopkins and David H. Sharp postulate a weakened US deterrent posture due to the lack of nuclear testing since 1992. The article implies that a return to testing is necessary to restore a higher level of confidence to underpin the on-going modernization of the

PHILLIP K. SMITH III, *Lucid Stead: Chromatic Variants, Yellow*, 2013-2019; Archival pigment print, 18 x 18 inches

PHILLIP K. SMITH III, *Lucid Stead: Chromatic Variants, Orange*, 2013-2019; Archival pigment print, 18 x 18 inches

nation's nuclear stockpile. From a purely technical perspective, nuclear testing certainly would increase our confidence, but at what price to our overall national security?

A return to nuclear testing would require, at a minimum, a series of costly nuclear tests that might result in resumed nuclear testing by other current nuclear weapons states and perhaps in the inception of nuclear testing by nonnuclear states that have nuclear aspirations. This is a risky path that should be taken only if absolutely necessary.

The US stockpile has been certified every year since 1997 through a detailed analysis carried out by the National Nuclear Security Administration nuclear weapon laboratories using the tools of the highly successful science-based Stockpile Stewardship Program (SSP), by the Department of Defense (US Strategic Command), and by independent groups advising the government. These rigorous certifications are based on weapons surveillance, nonnuclear experiments, previous nuclear tests, and computer simulations. If Hopkins and Sharp are correct in their assertion that the scientific foundation is eroding because any changes (aging, remanufacturing, etc.) in the stockpiled weapons are not "nuclear-tested, and that "we are gambling with our nation's nuclear deterrent" by trusting the SSP as the basis for certification, then we should not ignore their warning.

Given the current state of world affairs and the 25 years since the inception of the SSP, it might be time that an independent group be appointed to evaluate in depth the level of confidence we should have in our stockpile using the SSP without nuclear testing.

John C. Browne
Former Director (1997-2003)
Los Alamos National Laboratory

Congratulations are due to John C. Hopkins and David H. Sharp for their vitally important article, which has the potential to preserve America's existence. The authors, who are eminent senior scientists at the Los Alamos National Laboratory, had the education, experience, determination, and courage to pursue science and independent thought, while working within a bastion of political correctness.

The Cold War was the world's first nuclear war. It lasted for half a century, and was fought primarily in the world of nuclear science. The United States won it without detonating a single nuke, through superiority in science, strategy, and strength.

However, when that war ended in 1991, US leaders, supported by the public, caused the nation to embark on an unannounced nuclear weapons freeze that—more than a quarter-century later—is still in effect. Every weapon in the nation's arsenal is far beyond its design life. Not a single weapon has been tested during this period. Instead of testing, our nuclear scientists have relied on computer simulations. These computer codes have never been verified.

The authors, with decades of experience in design and testing of nuclear weapons, have produced the first scientific paper to demonstrate why America should not have confidence that our nukes will detonate when our existence depends upon them.

America must immediately resume underground nuclear testing by the Departments of Energy and Defense. We must have total confidence in our strategic nuclear deterrent. We are a quarter-century behind our adversaries in understanding the advanced nuclear sciences of weapons design and weapons effects. We are immensely vulnerable to technological surprise.

Robert R. Monroe
Vice Admiral, US Navy, Ret.
Former Director, Defense Nuclear Agency

SPACE MINING

In "New Policies Needed to Advance Space Mining" (*Issues*, Winter 2019), Ian Christensen, Ian Lange, George Sowers, Angel Abbud-Madrid, and Morgan D. Bazilian provide an excellent overview of the policy and legal challenges posed by space resources activities. The authors, experts in the field, clearly explain the challenges in space resources utilization that subsequently lead to the suggested need for new policies. Their main claim, that policies should be in place in order for space mining to evolve in a sustainable manner, is supported by four specific policy recommendations. The latter correspond to the discussions that are presently taking place in various forums and call for a holistic approach to space mining that will take into account not only the present state of technology and resource needs but also future advancement. Except from describing these recommendations, the authors do not suggest ways to initiate these policies, and although this might be outside the scope of their current article, a further elaboration of these recommendations would be welcomed.

One of the interesting points the authors raise is the identification of a major source of tension in the discussions on space mining; that is, the occasional misconception between commercial space mining activity and the general use of space resources. Whereas outer space is not subject to appropriation, all nations are free to explore and use it, according to international space law. We do not, however, concur with the authors' statement that commercial space resource activity "requires some possession right (not necessarily permanent) to regions in space." Though possession rights in the resources themselves are evidently needed, this is not allowed for "regions in space" as per Article II of the Outer Space Treaty.

By presenting various perspectives on the current status of the industry, it

becomes clear that the abovementioned misconception might not be fully justified. Despite the hardships of the two initial pioneering space mining companies (in fact, both Planetary Resources and Deep Space Industries no longer exist, having being acquired by other firms), several smaller private initiatives are currently developing, such as PTScientists in Germany and the Asteroid Mining Corporation in the United Kingdom. The development of an appropriate framework for the conduct of space resource activities is therefore urgent, and it is essential, as recommended, to involve industrial stakeholders in policy discussions.

With regard to the authors' use of the term "space mining," we note that the term has been considered to have negative connotation, as it might be suggestive of outer space use that does not correspond to the cooperative character of space activities. The preferred terminology is "space resources activities."

We agree with the authors' observation that space resources utilization is now generally seen as not prohibited under current international space law. Their article underlines the importance of interdisciplinary approach and interaction among different stakeholders on national, regional, and international levels in addressing the need for a framework to govern space resource activities. Law usually succeeds technological development in the field of space activities, and space resource utilization is a rare example of almost parallel development. Alongside the need for new policies as presented in this article, it should also be underlined that the momentum for policy to encourage the sustainable development of space resource activities should not be missed.

Tanja Masson-Zwaan
Dimitra Stefoudi
Leiden University
The Netherlands

Christensen et al. make the case for clarifying and streamlining domestic and international legal and regulatory policies to create a new industrial sector focused on space-based resource extraction. The authors are on the money when noting that space mining, or rather space resource extraction (not every resource in space is mined, an example being space-based solar power), is an important national priority for a variety of reasons, not least of which is ensuring US global leadership across all domains in space. The authors end their article by recommending four principles to guide policy formulation to enable the creation of a vibrant new industry.

The exclusive emphasis on policy and regulatory instruments puts the cart before the horse. The authors themselves acknowledge that the economic case for resource extraction is at best inchoate. Recent dissolution of asteroid mining companies such as Planetary Resources and Deep Space Industries shows that the state of technology and business viability of resource extraction is still nascent. Given these challenges, focus on policy and legal guidance, especially at the United Nations level, seems premature.

Although policy and legal frameworks could be helpful in developing global awareness, it would be most useful to promote policy developments in concert with two other dimensions: establishing the value of space resource extraction and ensuring technology development. The term value does not refer to commercial companies being able to make money (which we have already seen is not likely to happen in the near-term), but to the tangible societal value—including economic value—of space resource extraction. Given the falling cost of launch, it may not make sense in every possible architectural configuration to extract water (to make propellant, for example) from asteroids or the Moon and to have propellant depots in space. Part of establishing value means that we need to identify which architectures help make the case for space resource extraction and examine how realistic they are. For example, if the National Aeronautics and Space Administration human missions to Mars use chemical-solar or nuclear propulsion, the amount of chemical propellant required would not be enough to potentially cover the cost of a space-based propellant extraction system.

To examine the economic value, we need to know the cost of a space-based propellant extraction system, which has many steps: prospecting, transportation to and from celestial bodies of interest, excavation of raw materials, processing raw materials into a useable product, storing the product, and finally, use of the product by consumers. Other than prospecting, hardly any of these technologies can currently be considered ready. Technologies for excavation, processing, and storage are furthest behind. There is a clear need to create and mature technology for each of these stages.

It goes without saying that the economic value and technology development are iterative activities. We need to know the technology that will be used, say to extract water from the surface of the Moon, to be able to cost it, to ensure it will, at least eventually, be lower cost than carrying water from Earth.

Together with establishing a clear case for space-based resource extraction, government agencies and private entities, including universities and commercial companies, need to develop a plan to support and conduct the R&D required to take technology to high levels of readiness across all of the extraction and use fronts. As technologies mature, the community can engage more deeply to address the policy, legal, and regulatory issues, which, as the authors point out, are not without their own challenges.

Bhavya Lal
IDA Science and Technology Policy Institute

OCTOPUS FARMING

"The Case Against Octopus Farming" by Jennifer Jacquet, Becca Franks, Peter Godfrey-Smith, and Walter Sánchez-Suárez (*Issues*, Winter 2019) deserves a wide audience.

Most readers will already be aware of the damage that overfishing is doing to the world's oceans, but some of them may believe that aquafarming alleviates this problem. In fact, as the authors point out, when we farm carnivorous species such as octopus, we need to catch three kilograms of fish for every kilo of octopus produced.

Even if that were not the case, however, what kind of human chauvinism is implied by the assumption that we can take animals from any species we wish, irrespective of how little we may know about their cognitive abilities, their social relationships, and their welfare needs, and crowd them into small spaces in order to produce them more cheaply? Nor are we doing this to feed the hungry—the market for farmed octopus is largely affluent and well-fed.

Industrial animal production is ethically indefensible, whether the animals are pigs, chickens, cows, or octopuses. Still, many consumers find it difficult to imagine giving up chicken, pork, beef, or milk, and buying these products from free-range producers could strain their budgets. That doesn't justify buying these animal products from industrial farms, but it does explain why those nightmarish animal factories exist. When it comes to subjecting millions of intelligent, sensitive animals, from a species never before domesticated or farmed, to industrial-scale captivity in order to increase the market for a luxury food, however, the arrogance with which we humans are behaving toward other animals is revealed in all its stark brutality.

Peter Singer
Ira W. DeCamp Professor of Bioethics
Princeton University
Laureate Professor
University of Melbourne

Jennifer Jacquet et al. have penned a diatribe against octopus farming with considerably more heat than light, using generalized assumptions and selected facts. I would like it if no one killed and ate the intelligent and fascinating octopuses that I work with, either caught in the wild or farmed in captivity. But I am a realist; people have to eat. And as the authors point out, octopuses have many characteristics that make them good candidates for "farming." They have a stunning conversion rate of 50% from food ingested to flesh put down (not the 30% noted in the article). They gain weight very quickly, 2% per day if well fed, and reproduce after a year or two and produce many offspring. Hiding in confined spaces, they are well adapted to captivity. They are carnivores, but so are commonly farmed salmon.

The authors predict that farmed octopuses will be a luxury item in "upscale outlets." Maybe for people in northern European countries, but cephalopods continue to be an important food source for Mediterranean countries and all across Asia, often caught by artisanal fisheries and consumed by a wide swath of the populations. People will not "pay more" for wild-caught octopuses, and rather than being "increasingly scarce," octopus populations are increasing; it is only a few local populations that are "in decline." Capture of wild octopuses is not always carried out ethically, either. Many marine animals are simply dumped on the deck of ships, to die of the equivalent of suffocating. One postcapture treatment is to dump the octopus into a barrel of fresh water. The animals die slowly and absorb water, sold subsequently at market at a higher weight due to the added liquid, an unethical and cruel practice. Killing them instantly by destroying the brain is the best technique, carried out by some fishers by biting the octopus between the eyes (not for the squeamish).

The authors seem to have a uniformly negative view of keeping animals in captivity for food as "cruel to individual animals" and "environmentally unsustainable." They predict that farmed octopuses are likely to have "high mortality rates and increased aggression, parasitic infection, and a host of digestive tract issues." Perhaps because they write from the United States, the authors have this poor view of animal welfare and ethics. In Canada where I live, consideration of ethical issues for cephalopods in research has been in effect since 1999. In the European Union, Directive 2010/63/EU requires that cephalopods be given ethical consideration in research, captivity, and during fishing. The United States has no regulation on what you can do to any invertebrate. Perhaps the authors, instead of condemning farming of octopuses, should direct their effort to encouraging similar regulations and making captivity a better situation for octopuses and other similarly held animals.

Jennifer Mather
Professor of Psychology
University of Lethbridge
She is the author of *The Octopus Scientists: Exploring the Mind of a Mollusk*

CLIMATE PHILANTHROPY

In "Climate Philanthropy and the Four Billion (Dollars, That Is)" (*Issues*, Winter 2019), Matthew C. Nisbet makes the argument that investments in climate change mitigation by large foundations have been too narrow in scope to help avert global catastrophe and that the growing influence of philanthropy in solving the climate crisis creates a problem of accountability, where the unelected leaders of foundations seek to exercise global power.

Nisbet is correct in his central argument that a wider set of solutions beyond simply deploying renewable energy and putting a price on carbon is required. The most recent United Nations Intergovernmental Panel on Climate Change (IPCC) report lays out, in stark detail, the calamity the world is facing and the need for urgent and extreme action to dramatically reduce emissions to limit global temperature rise to 1.5 degrees Celsius this century. That's why, at the John D. and Catherine T. MacArthur Foundation, we're advocating an "all-in" approach in

our support of climate solutions. That must include the rapid deployment of renewables and limits on greenhouse gas emissions, which include carbon dioxide, but also shorter-lived yet more potent gases such as methane coming from natural gas production and agriculture. We must also work with the energy industry to explore carbon capture and storage solutions, including the potential of direct-air capture, and to expand the use of safe and secure nuclear power that does not increase the risk of weapons proliferation.

Where we question Nisbet's argument is in his assertion that growing and unaccountable philanthropic investment in climate solutions will surpass national governments in their ability to define the agenda on climate change. Though foundation trustees, presidents, and staff may wish they had that sort of influence, it is hardly the case.

In 2018, MacArthur joined 28 of the world's largest foundations in pledging $4 billion in grants to accelerate the transition to clean energy and reduce the world's emissions. That is a lot of money, but not nearly what it will take to offset the $54 trillion in damage the IPCC report says a 1.5-degree temperature increase will cost the world. That same report says the world needs to double its current energy investments to $2.4 trillion each year between now and 2035, largely on clean energy. And though philanthropic support may help strengthen the civil society actors and innovators working to accelerate climate solutions, a report in 2018 by Drexel University found that fossil fuel producers, airlines, and electrical utilities outspent such groups 10 to 1 in lobbying on climate change legislations between 2000 and 2016.

So, while big philanthropy can certainly help drive an agenda and make key strategic investments, its resources pale in comparison to the more powerful forces we all must increasingly engage with to solve this problem: government and industry. Indeed, it is time to "build a broader political coalition that seeks out nontraditional allies and welcomes challenging ideas," as Nesbit writes. We have also called for that conversation and for stronger government leadership on climate from the city level on up. We encourage greater investment by both industry and government in climate solutions, and we look forward to being a partner in saving our planet.

Jorgen Thomsen
Director, Climate Solutions
MacArthur Foundation

Matthew Nisbet's article is an important contribution to the discussion about the role of philanthropy in addressing climate change. As he notes, climate philanthropy has resulted in several significant achievements. Yet I share his core concern that "as funders have invested in a common road map for tackling climate change, their preferred framing has become so pervasive…that most advocates, journalists, and academics no longer perceive…that there might exist alternative interpretations and courses of action to consider."

I have witnessed this dynamic firsthand through my own work in climate philanthropy. Given the tremendous lift that it will take to decarbonize the global power supply, let alone transportation, buildings, and industry, I am of the belief that we should be expanding the set of potential tools at our disposal. But more than a decade of philanthropy and advocacy has been focused on a narrow tool kit—primarily solar, wind, energy efficiency, and carbon pricing—that is unlikely to solve this challenge on its own (at least if the United Nations Intergovernmental Panel on Climate Change and other credible agencies are to be believed).

In contrast to the well-funded environmental groups that Nisbet describes, the organizations working to advance policies regarding other potential solutions, such as advanced nuclear power, carbon removal, carbon capture, sunlight reflection, and broad-based innovation policy, are deeply underfunded. And though some longtime climate funders such as the Hewlett Foundation have begun to meaningfully widen the scope of their grantmaking, traditional climate philanthropy has been too slow to acknowledge that its funding patterns run the risk of contributing to a "dangerous path dependency," as Nisbet puts it.

Where I respectfully disagree with Nisbet is that I think he overstates the power of big philanthropy to set the climate agenda. In many cases climate foundations are actually following the priorities set by their grantees. And despite Nisbet's claim that philanthropists are "likely to surpass national governments in their ability to define the agenda on climate change," money isn't everything, and the power of public leaders to set an agenda remains unparalleled—even in an era of gridlock and dysfunction. The Green New Deal, which was not funded by big philanthropy, is just the latest reminder of this.

However, what the Green New Deal and much of the work funded by traditional climate philanthropy have in common is that they are well-intentioned but problematic agendas for building effective political constituencies on climate change. We need climate solutions that can help decarbonize the economy and break through partisan gridlock. Witness the passage in the last (highly polarized, highly dysfunctional) Congress of two nuclear innovation bills, the Nuclear Energy Innovation and Modernization Act and the Nuclear Energy Innovation Capabilities Act, both of which had strong bipartisan support.

Accelerating the pace of this work in order to meet the climate challenge requires building a new field of institutions that can work alongside big green groups to provide a diversified approach to addressing climate change. In my view, that is climate philanthropy's most urgent task.

Rachel Pritzker
President
Pritzker Innovation Fund

FROM THE HILL

With the end of the border wall brouhaha, Congress passed omnibus legislation that set funding levels for fiscal year 2019. As anticipated, the budget includes substantive increases for key science agencies including the National Aeronautics and Space Administration (NASA), the Department of Agriculture (USDA), and the National Science Foundation (NSF). This builds on previous congressional actions to boost research at the National Institutes of Health (NIH), the Department of Defense (DOD), and the Department of Energy (DOE). Agencies focused on environmental and climate research—the Environmental Protection Agency (EPA), the US Geological Survey (USGS), and the National Oceanic and Atmospheric Administration (NOAA)—were protected from the administration's proposed cuts (see Figure 1 for comparisons).

AAAS currently estimates R&D spending in the FY 2019 omnibus at $151.5 billion, an increase of 6% or $8.6 billion above FY 2018 estimated R&D. This increase was enabled by the 2018 bipartisan budget deal, which raised the discretionary spending caps for FY 2018 and FY 2019. Looking ahead, the new Congress will need to negotiate another budget agreement that would raise spending limits in FY 2020 and FY 2021, the final two years subject to sequestration legislation that called for tight limits on federal spending.

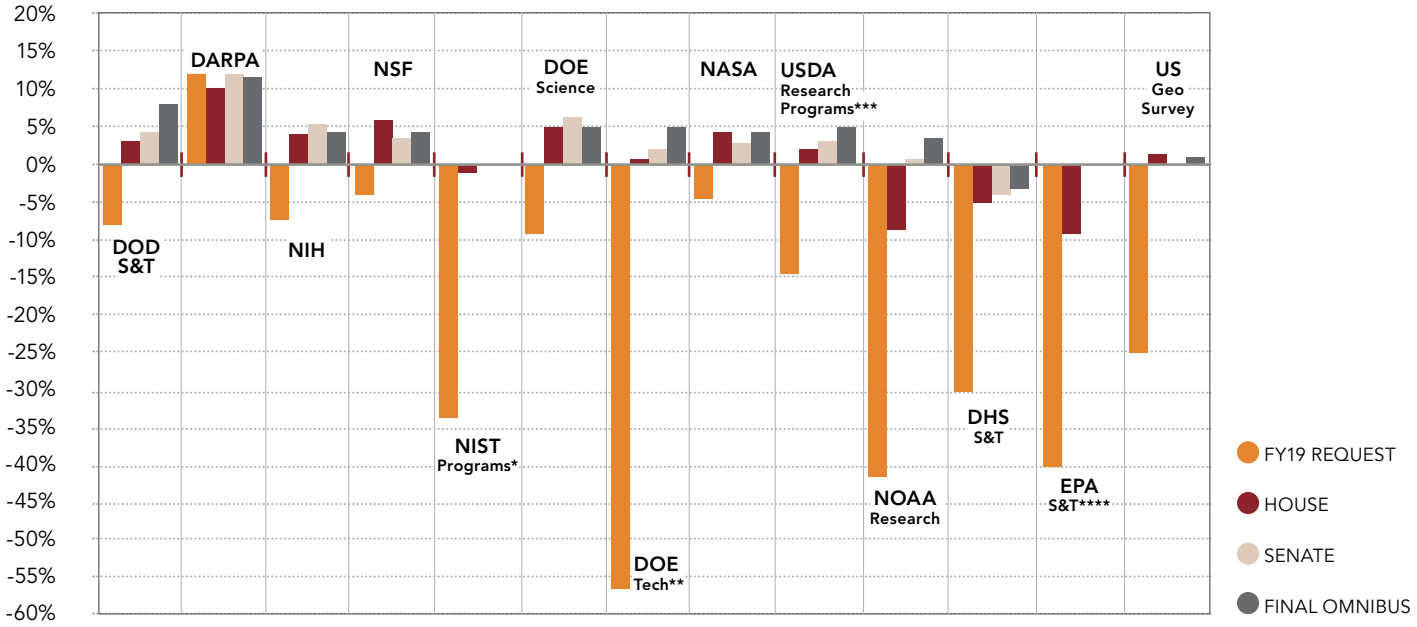
A deeper look into the omnibus reveals that basic research would fare somewhat better than applied research, as seen in Figure 2. This reflects strong congressional support for key basic science agencies, including NIH, DOE's Office of Science, NSF, NASA's Science Directorate, and DOD. In contrast, Congress had sought more limited changes for the larger applied research funders such as USGS and DOE's technology offices.

Total research (basic and applied) in the omnibus is roughly $86.5 billion—the highest amount ever for such spending. Research as a share of gross domestic product (GDP) in FY 2019 would fall slightly to 0.41%.

National Science Foundation. NSF is slated for a moderate 4% increase overall, roughly the same growth rate as in FY 2018. The agency's core research account was given a 2.9% increase, which is not quite as much as envisioned by House appropriators. NSF's Education Directorate received a targeted increase for the Hispanic-Serving Institutions Program. The omnibus funds construction of three research vessels rather than the two requested by the administration and initiates funding for the Antarctic Infrastructure Modernization for Science

Fig 1. **Select Science & Tech Agencies and Programs in FY 2019 Appropriations**

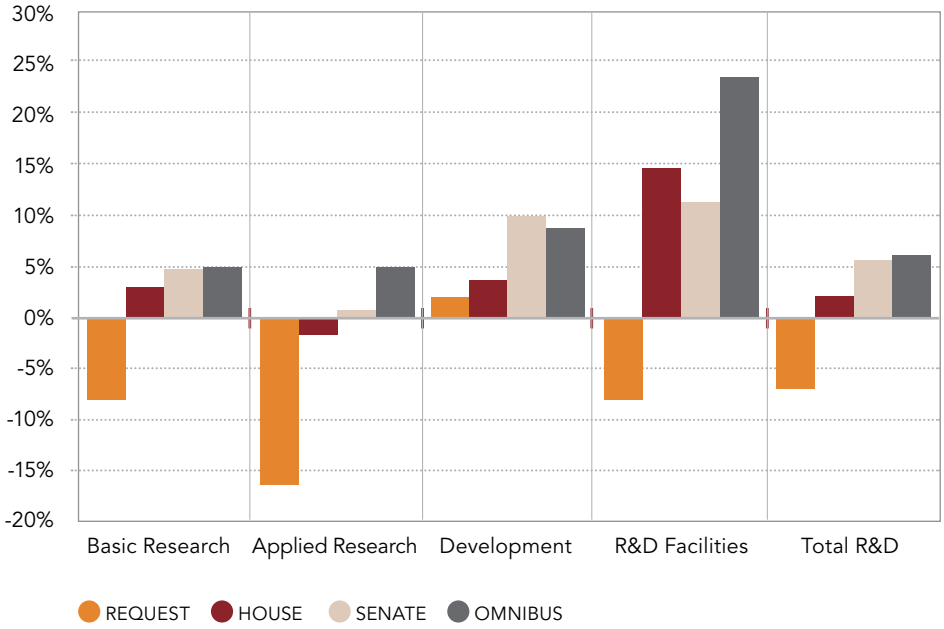
Estimated percentage change from FY 2018 enacted omnibus, nominal dollars



*Includes labs and industrial technology, excludes construction; flat in Senate and omnibus. **Includes renewables and efficiency, nuclear, fossil, grid research, cybersecurity, ARPA-E. ***Includes ARS, NIFA, ERS, NASS, Rangeland Research, excludes ARS construction. ****Flat in Senate and omnibus.

Fig 2. **R&D by Type in FY 2019 Appropriations**

Estimated percent change from FY 2018, nominal dollars



AAAS estimates based on OMB, agency, and Congressional data. © 2019 AAAS

project, part of a long-range investment program for McMurdo Station.

NASA. The space agency was granted a large $764 million boost in the omnibus, building on recent budget growth. NASA's FY 2019 budget totals $21.5 billion, which is just shy of the agency's peak in FY 2010, after adjusting for inflation. Exploration programs and planetary science were the big winners, with robust funding for the Europa mission and the new lunar gateway, and Earth Science was shielded from the administration's proposed cuts. Notably, the Wide Field Infrared Survey Telescope—the highest priority astronomy mission in the latest decadal survey—was spared from the White House attempt to eliminate it.

Other notable outcomes:

- NASA's Space Launch System (SLS) obtained an additional $48 million for construction of a second mobile launch platform, which will be ready by 2024. The administration did not request funding for the second platform.
- The new Lunar Discovery and Exploration Program received $218 million to develop instruments and other payloads for missions on the Moon's surface.
- The robotic satellite servicing spacecraft known as Restore-L secured a $50 million boost requested by Senate appropriators, whereas the House and administration sought to limit its overall cost.
- As part of the 5.8% increase for NASA Aeronautics, the omnibus includes no less than $35 million for hypersonic research aimed at solving the challenges of high-speed flight.
- James Webb Space Telescope (JWST) development is fully funded thanks to a provision in the bill that adjusts the cap for the telescope to $8.8 billion, an increase of about $800 million above the previous cap. The bill warns that "NASA should strictly adhere to this cap or, under this bill, JWST will have to find cost savings or cancel the mission."

Department of Agriculture. USDA's intramural Agricultural Research Service (ARS) was handed an 8.5% increase for core research, alongside a massive $381 million total for construction and modernization of research facilities in accord with the agency's capital improvement strategy. Meanwhile, the extramural National Institute of Food and Agriculture (NIFA) received a 4.5% increase, which is above both House and Senate appropriations levels. The Agriculture and Food Research Initiative (AFRI), the department's competitive grants program, ended up with the higher House-proposed level of $415 million, a 3.8% increase above FY 2018 levels.

Another noteworthy outcome: the legislation sidelines the administration's attempt to relocate the Economic Research Service and NIFA out of the National Capital Region and directs USDA to report on the costs and benefits of the proposed move as part of the FY 2020 request. However, Congress approved the transfer of National Bio and Agro-Defense Facility (NBAF) operations from the Department of Homeland Security (DHS) to USDA. NBAF will serve as a biosafety level 4 research center when construction is completed within the next five years.

National Oceanic and Atmospheric Administration. NOAA's core Office of Oceanic & Atmospheric Research (OAR) was given an overall 3.2% increase, with limited funding gains across most research programs. Climate research was spared the large cut requested by the House and administration. Also protected from elimination was the National Sea Grant College Program, which received a $3 million increase to $68 million. The US Weather Research Program saw a $3.9 million funding uptick, and funding for ocean exploration and research was increased by $5.5 million.

Funding for the Geostationary Operational Environmental Satellite (GOES-R) and the Joint Polar Satellite System (JPSS) were subject to funding reductions in line with House and administration levels, reflecting a scheduled ramp-down of both programs. Meanwhile, funding for the Polar Follow-On (PFO) was decreased by $89 million to a total $330 million in FY 2019. NOAA's proposal to combine

the PFO with JPSS was rejected, but will continue to be considered by Congress.

National Institute of Standards and Technology (NIST). Two initiatives, the Hollings Manufacturing Extension Partnership and Manufacturing USA, were flat-funded at FY 2018 levels. The administration had sought cuts or outright eliminations of these programs. Following a large one-time boost in last year's omnibus, NIST's research facilities construction account is slated for a 67% funding drop.

Environmental Protection Agency. Congress dismissed the administration's proposed 24% cut to the EPA budget and provided an overall flat appropriation. EPA's Science & Technology account is correspondingly flat, versus a severe 40% cut requested by the administration. Climate change research grants were protected from proposed elimination.

Congress also rejected the administration's attempts to implement a "workforce reshaping" program that would have reduced the number of EPA scientists through organizational restructuring. Meanwhile, the bill continues to prohibit EPA from using funds to implement a mandatory greenhouse gas reporting system for livestock producers.

In total, the FY 2019 omnibus would leave EPA's estimated R&D budget approximately 36% below FY 2005 levels, after adjusting for inflation.

US Geological Survey. The agency's total budget is up by 1.1%—a better outcome than the 25% cut proposed by the administration. Most research areas saw limited funding change. Energy and mineral resource activities received the largest increase, with $9.6 million provided for a new critical mapping initiative and $3.8 million to jump-start energy production in the National Petroleum Reserve in Alaska. Climate Adaptation Science Centers funding, which the administration sought to cut, remains equal to FY 2018.

Meanwhile, the National Land Imaging Program was granted a $5.8 million increase, but core land-change science was flat-funded. Landsat-9 is fully funded at $32 million. The Earthquake Early Warning System was shielded from proposed elimination and flat-funded, and the Volcano Hazards Program was trimmed.

Notably, the omnibus includes funding that allows the Interior Department to implement reorganizations as part of an overhaul plan spearheaded by former Interior secretary Ryan Zinke. The proposed reorganization has raised concerns within the scientific community. The omnibus legislation does, however, urge the department to notify and consult with Congress about planned workforce restructures and reshaping.

Department of Homeland Security. The agency's science & technology account was cut by a total of $21 million below FY 2018, largely as a result of the transfer of operational responsibility for the National Bio and Agro-Defense Facility from DHS to USDA, as noted above. Core research and development funding was essentially flat-funded. University programs would also remain equal to the FY 2018 level of $41 million. The omnibus agrees with the administration's request to replace the Domestic Nuclear Detection Office with a new Countering Weapons of Mass Destruction Office funded at $435 million, with $83 million for R&D programs.

Census Bureau. As part of the ramp-up toward the 2020 decennial headcount, the United States Census Bureau received a full $1 billion increase, matching the Senate and administration's proposed level.

More budget news

Administration to propose FY 2020 budget cuts. In an op-ed published February 25, the acting director of the White House Office of Management and Budget, Russ Vought, signaled that the administration plans a 5% cut to nondefense discretionary spending, which includes funding for key research agencies, in its FY 2020 budget request. It's unclear what baseline the administration is using; nondefense spending is currently scheduled to drop by about 9% in FY 2020 under the Budget Control Act (BCA) spending caps (see related item below). Meanwhile, Vought indicated that the administration intends to increase defense funding using the Overseas Contingency Operations account, which is not subject to the BCA spending caps. Fiscal conservatives have previously criticized use of that account as a way to get around the spending caps.

Will budget sequestration be blocked again? On February 27, the Senate Budget Committee held a hearing to review the Budget Control Act, with the assistant director for budget analysis at the Congressional Budget Office, Terri Gullo, the sole witness. The BCA, which was signed into law in 2011, mandated across-the-board cuts known as "sequestration." Under the BCA, the discretionary portion of the budget, which funds virtually all R&D programs, is set to drop by $126 billion or 10% in FY 2020. Congress previously acted to roll back the sequestration caps through a series of two-year budget deals. Reaching another bipartisan agreement to lift the spending caps would provide greater fiscal room for science investments.

GAO seeks larger S&T role. In late February, the Government Accountability Office (GAO), a legislative branch agency that focuses on auditing and evaluating federal programs, announced that it is seeking a $50.3 million budget boost to $686 million for FY 2020. One purpose of the increase is to support GAO technology assessment efforts, an emerging role of importance for the agency. The GAO established a new Science, Technology Assessment, and Analytics office earlier this year.

House says no to earmarks. House Appropriations chairwoman Nita Lowey (D-NY) announced that the House will continue to prohibit budget earmarks in its FY 2020 appropriations bills. Lawmakers in both chambers have been debating whether to resurrect earmarks, which have been banned since 2011.

NIH addresses sexual harassment

The director of the National Institutes of Health, Francis Collins, and several senior

NIH officials released an update on the agency's efforts to address sexual harassment in science. "To all those who have endured these experiences," the statement says, "we are sorry that it has taken so long to acknowledge and address the climate and culture that has caused such harm. The National Academies report on sexual harassment of women in science found that 'federal agencies may be perpetuating the problem of sexual harassment.' We are concerned that NIH has been part of the problem. We are determined to become part of the solution."

A working group of the Advisory Council to the Director plans to release interim recommendations in June. In the meantime, NIH has been working to demonstrate accountability and transparency regarding sexual harassment, clarify expectations for institutions and investigators, provide clear channels of communication to NIH, and listen to victims and survivors and incorporate their perspectives into future actions. In 2018, NIH followed up on complaints from more than 24 institutions, resulting in the replacement of 14 principal investigators on NIH extramural grants. The awardee institutions themselves took disciplinary action against 21 principal investigators, including termination in some cases.

Fourth space policy directive signed

On February 19, President Trump issued Space Policy Directive-4 to further establish a US Space Force. The directive requires the secretary of defense to develop and submit to the Office of Management of Budget for the president's approval a legislative proposal establishing a US Space Force as an armed service within the Department of the Air Force. The legislative proposal is to outline how the Space Force will "organize, train, and equip forces to provide for freedom of operation in, from, and to the space domain; to provide independent military options for national leadership; and to enhance the lethality and effectiveness of the Joint Force."

OSTP comes to life

In early February, the White House Office of Science and Technology Policy (OSTP) issued a report, *Science & Technology Highlights in the Second Year of the Trump Administration*, outlining the achievements of the administration in a range of areas, including artificial intelligence, cybersecurity, lab-to-market initiatives, ocean science, R&D fundamentals, and space exploration. Some of the achievements highlighted include signing legislation to encourage advancements in unmanned aircraft systems technologies, supercomputer development, and increased investments in artificial intelligence research. The report was released shortly after OSTP welcomed its new director, Kelvin Droegemeier, and with its release, the agency tweeted, "As our Nation stands on the verge of a new era in science and technology, OSTP looks forward to continued work to ensure that American researchers lead the world, and that the United States remains the best place on Earth to explore, create, and innovate."

Droegemeier gave his first official speech to the scientific community at the AAAS annual meeting in Washington, DC, in February. He discussed the US R&D ecosystem and highlighted three pillars that OSTP will address as a means of developing a new construct for the nation's innovation system. The first of the three pillars involves conducting a quadrennial assessment of the nation's research enterprise, including the four sectors that fund research: government, academia, industry, and the private sector. A second pillar involves creating new partnerships and areas of collaboration between the sectors as a means of leveraging its collective strength, and a third pillar will focus on reducing the regulatory burden on the research enterprise.

Call for national research policy board

Stating that the United States has a "fractured, inefficient, inconsistent system" to foster research integrity, the authors of an article in *Nature*, including National Academy of Sciences president Marcia McNutt, have called for the establishment of a national research policy board. Because individuals in the research enterprise typically meet only with their peers, the board would bring together individuals from all sectors of the research community—including funders, journals, academic administrators, and others—to determine best practices in setting an environment of scientific quality and integrity. The board would not adjudicate allegations of research misconduct.

Warning of foreign influences on research integrity

An NIH-appointed panel of experts has warned that US institutions receiving money from NIH need to tighten their security procedures. The eight-member panel, which includes five university presidents, was commissioned to investigate "foreign influences on research integrity" and presented its findings to NIH director Francis Collins in January. In a subsequent letter to more than 10,000 institutions that receive NIH grants, Collins and FBI director Christopher Wray warned about "non-traditional collectors of information" and presented cases where data thieves had shared intellectual property with Beijing, run "shadow laboratories" in China, and stolen confidential information from grant applications.

Although peer review violations are uncommon, several NIH institutes have confirmed "breaches in the integrity" of the peer-review process, and Collins stated that "the magnitude of these risks is increasing." The Trump administration has moved to limit the duration of visas for some Chinese students in certain high-tech fields. Collins acknowledged that the "vast majority" of foreign nationals make valuable contributions to US science, but Wray told Congress last year that the "level of naïveté on the part of the academic sector about this creates its own issues."

"From the Hill" is derived from the weekly Policy Alerts and the reports of the R&D Budget and Policy Program of the American Association for the Advancement of Science.