

postdoc at Johns Hopkins University who works on orchestrating self-assembly of microparticles using genetic regulatory networks. He goes into the lab two or three times a week. "I see people in the lab, but because we all know the time [for experiments] is limited, there is much less interaction than before the pandemic." For theorists, going onto campus likewise doesn't increase interactions, says Penn's Liu, "but it does offer a quiet workplace for some people."

COVID-19 testing is the key to staying open for many universities. At UIUC, for example, entry to campus requires being tested twice a week. The University of Arizona introduced testing with saltwater gargling samples, which is more sensitive and comfortable than the nasal swab. Through wastewater monitoring, last August that university also discovered two positive cases in a dormitory with several hundred residents. At Hamilton College in upstate New York, condensed-matter experimentalist Viva Horowitz says she feels less stress about going to campus because everyone is tested regularly. As for the students, she says, "they may be more afraid of being quarantined than of catching the disease." Horowitz says the "darkest moments" of the lockdown came when she realized she was afraid to spend the holidays with her mother and grandmother and was upset not to.

Horowitz studies diamond nitrogen-vacancy centers and two-dimensional materials. She was supposed to go up for tenure this year but has accepted her institution's offer to delay by a year. "The pandemic slowed down my research because of lack of lab access and for emotional reasons," she says. It also interrupted existing and new collaborations with colleagues around the country. "I don't know if a

tenure delay or anything could make things fair," she says. "The university can't make it right that I was making research plans that I can no longer carry out."

Most institutions are offering an option to pause the tenure clock. Other measures campuses have taken to help faculty and students include inviting them to submit a statement with their promotion and tenure applications about how COVID-19 has affected their work, skipping student course evaluations (see PHYSICS TODAY, January 2020, page 24), extending deadlines for dropping courses, and installing improved air filters. The University of Arizona's College of Science created an emergency committee to guide graduate students and postdocs in campus reentry during COVID-19, says physicist Elliott Cheu, the college's interim dean. "Some teaching assistants were worried about teaching in person. It was getting dicey," he says. The college decided case by case whether in-person teaching was necessary.

Vashti Sawtelle is on the faculty at Michigan State University, where her research focus is physics education. She has two small children and shares childcare with another family; her husband is an essential worker. The university has done nothing to help with childcare, she says, but it did conduct a survey, and just telling the college how the pandemic affected her work life was "a big deal." One thing that has been hard on her mental health is that "it seems everyone expects you to have sorted things out by now, without any formal acknowledgment of what each family is dealing with. Academia wants you to keep doing what you usually do."

Money is another source of uncertainty. Institutions have allocated funds for COVID-related expenditures; testing

alone can cost millions of dollars. UIUC is making funds usually used for travel available to students to cover insurance copays for off-campus counseling visits, says Cooper. At the University of Arizona, some departments have hired additional graders for large classes. At the same time, many institutions have frozen hiring and are being forced to cut budgets. Speck at San Antonio, for example, had to cut spending in her department by 15%. "We combined large online introductory classes and cut about seven adjunct faculty," she says.

Individual principal investigators have mostly continued to pay their graduate students and postdocs. NSF and other funding agencies have largely permitted "no-cost extensions," which allow researchers more time to spend existing awards. Although there was some talk about "cost extensions," which would have provided more money to existing grants, that hasn't materialized. Given people's lower productivity, PIs are concerned about accomplishing what they promised and winning future grants.

James Pennebaker, a social psychology professor at the University of Texas at Austin, has studied a decade's worth of language in Reddit comments. "COVID has had an unbelievably big effect in the degree of anxiety that people express," he says. One marker, he explains, is that people's comments have become "stupider and less logical." For some individuals and groups, the pandemic is especially tough, he says, pointing in particular to people who live alone and to young people "who are at an age where they need to network." In the academy, he says, "everyone is a bit terrified about the implications of the economy and funding for basic research."

**Toni Feder**

## The undermining of science is Trump's legacy

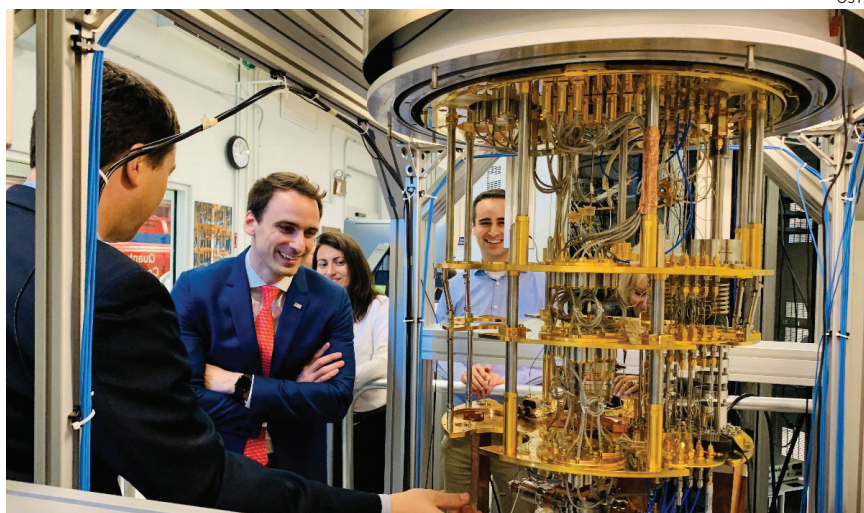
The past four years saw interference in the scientific process, inaction on climate change, and a weakened federal science workforce. Artificial intelligence and quantum information science benefited.

"It's fair to say that in the scientific community, the four years of the Trump administration are going to be remembered as an intense moment of searing

pain, one that is best forgotten as soon as the damage is repaired," says Representative Bill Foster (D-IL), Congress's sole PhD physicist.

"It would have been hard to imagine a president doing as much damage to science and Americans' trust in science and the application of science to so many problems this country faces," echoes Neal Lane, science adviser to President Bill Clinton and a former NSF director. "We've been through four years of hell."

"At the broadest level, on discussion of the issues in our body politic, [the Trump



**MICHAEL KRATSIOS**, the Trump administration's chief technology officer, visited Fermilab in October 2019 to learn more about the lab's quantum research efforts.

administration] did terrible harm to any fact-based discourse," says Richard Moss, a visiting researcher at Princeton University and director of the US Global Change Research Program in the Clinton and George W. Bush administrations. He laments "the corrosive effect it's had on discussion of all manner of issues, from climate to COVID-19 . . . where facts no longer matter."

Nowhere did fact-based discourse suffer more than on climate change; Donald Trump not only denied the existence of a threat, famously calling it a "hoax," but actively undid the steps taken by his predecessor Barack Obama to mitigate greenhouse gas emissions. In addition to withdrawing the US from the 2015 Paris Agreement, Trump encouraged the increased consumption of coal and replaced the Obama administration's Clean Power Plan, which had tightened limits on carbon emissions from power plants, with greatly relaxed standards. A federal appeals court threw out Trump's plan on 19 January, effectively reinstating the Clean Power Plan.

Trump also eased Obama's vehicle carbon emissions caps and took legal action to overturn California's and 14 other states' authorities to continue adhering to the Obama-era tailpipe limits. The controversy confused and divided the auto industry on which limits it should follow. Litigation on those issues continues.

Trump appointed emeritus Princeton University physicist William Happer, an outspoken climate skeptic, to a White

House advisory post. And Trump's advisers seriously considered former Department of Energy undersecretary Steven Koonin's proposal to conduct a "red team-blue team" debate that would pit the views of the small cadre of climate deniers and skeptics against those of the vast bulk of climate scientists. The idea, which was supposed to produce a consensus on the seriousness of the climate issue, was ultimately dropped.

"Policymakers' understanding of climate science suffered greatly by the president's denial of the problem," says Alice Hill, a senior fellow at the Council on Foreign Relations (CFR) and a National Security Council staffer in the Obama White House. "We saw the disappearance of the term 'climate change' from key strategic documents like the national security strategies and FEMA's [Federal Emergency Management Agency's] annual report on the preparedness of the nation for natural hazards." FEMA, she notes, "carries a heavy burden of responding to climate disasters."

But Kelvin Droegemeier, the director of the Trump White House Office of Science and Technology Policy (OSTP), points out that climate research continued at NSF, the US Geological Survey, DOE, and NOAA throughout the Trump years. "Was it a high priority of the administration? Clearly not as much as other administrations. That doesn't mean there wasn't scientific progress.

"Science is not the only thing that informs policy," says Droegemeier, noting

that national security, economics, and politics are other considerations. "My job as director of OSTP was to make sure that science was at the table and that we were ensuring we had the best quality science results available."

Lane empathizes with Droegemeier. "You had people in the OEOB [Old Executive Office Building, where OSTP is housed] trying to do important things, while across the parking lot in the West Wing it was chaos, with anti-science, anti-truth, anti-everything. I've got to hand it to the career people at OSTP and other agencies who stuck it out. I can imagine how excited they are that science is again going to be listened to in the West Wing."

Droegemeier, who's returned to the University of Oklahoma as a meteorology professor, lists budget increases for artificial intelligence (AI) and quantum information science (QIS)—with a goal to reach \$10 billion annually within five years—among the administration's science and technology accomplishments.

Droegemeier notes that AI quickly proved its usefulness in the pandemic, after he and science ministers of other nations called on journal publishers to immediately open up their coronavirus-related content in machine-readable format. "People brought their AI tools from around the world to bear on COVID publications that were coming out at a fire-hose pace," he says.

Foster acknowledges the White House achievements in AI and QIS, but he notes that "a lot of it was forced by increased competition from China and the rest of the world. Any administration would have done that. To their credit, people in the trenches at DOE and elsewhere made those programs happen."

## Funding improves

To be sure, the nation's federal and academic basic research apparatus enjoyed funding increases throughout the Trump years—despite the president's intentions. "Every February, Trump would propose horrific cuts across the board, and to the credit of Republicans and Democrats in the House and Senate, they stood up and said, 'No, this will do damage to the country,'" says Foster.

Federal R&D appropriations rose to \$165 billion in fiscal year 2021, from \$118 billion in FY 2018, according to estimates from the American Association for the Advancement of Science. Those

numbers don't include emergency spending related to the coronavirus, for which numbers aren't yet available.

The largesse was widely spread, led by the National Institutes of Health, where funding rose over the four years from just below \$37 billion to \$43 billion, according to FYI, the American Institute of Physics's science policy news source. NSF-sponsored research increased from \$6.3 billion to \$6.9 billion, while DOE basic R&D (excluding weapons and applied research programs) made similar gains, from \$6.3 billion to \$7 billion, according to FYI.

NASA's budget rose from \$20.7 billion to \$23.3 billion, with most of the growth devoted to human spaceflight. Trump countered Obama's agenda by ordering the return of astronauts to the Moon, but his goal of a lunar landing by 2024 was unrealistic, especially given Congress's refusal to provide anything close to the agency's budget requests for the Moon program. Critics of the selection of conservative representative Jim Bridenstine (R-OK) for NASA administrator were pleasantly surprised with his competent and largely apolitical management of the agency.

## Research security

Critics acknowledge that in sensitive fields such as AI, QIS, and biotechnology, the OSTP made headway in balancing two priorities: maintaining international scientific openness in academia and protecting US intellectual property and research assets from foreign adversaries such as China. A three-year process that involved Droegemeier's own input gathering from universities around the country culminated in the issuance of a national security presidential memorandum in the waning days of the administration. The document spells out uniform guidelines to the federal agencies for vetting sponsored researchers on their involvements with foreign organizations.

Lane credits those efforts with helping defuse "crazy" threats by some lawmakers to ban all foreign students and international scientific cooperation.

The COVID-19 pandemic brought about an unprecedented rapid scale-up and redirection of research into vaccines



**THE ALASKAN VILLAGE** of Kivalina on the Arctic Ocean is threatened by sea-level rise from climate change. Interior Department scientist Joel Clement was removed by Trump administration appointees from his job helping Arctic communities adapt to their shifting environment. He was reassigned to an office that collects royalties from oil and gas leases.

and other therapeutics at several federal agencies. "I coordinated with NIH, DOE, NSF, and NIST to make sure we were getting money out the door quickly," Droegemeier says. Scientific computing and physics instruments at the national laboratories were directed to finding treatments for the disease (see *PHYSICS TODAY*, May 2020, page 22).

At Droegemeier's urging, NSF lifted the \$200,000 cap on Rapid Response Research grants for coronavirus-related R&D. The funding mechanism allows accelerated review and award of funding for research addressing urgent needs.

But scientific progress against the pandemic was repeatedly undermined by Trump's endorsements of ineffectual treatments and his rejection of scientific advice. In particular, Trump sidelined Anthony Fauci, director of the National Institute of Allergy and Infectious Diseases, and Deborah Birx, the White House coronavirus response coordinator. In their place, he installed Scott Atlas, a radiologist who argued that the virus should be allowed to spread largely unimpeded.

## Legacy of interference

An indisputable legacy of the Trump administration was an unparalleled level of political interference with science—data disappeared, scientists were silenced, and science-based policy was ignored or compromised. Perhaps the most far-

reaching example of attempted interference was at the Environmental Protection Agency; an initiative, originally proposed by then administrator Scott Pruitt, sought to change the agency's process of setting individual exposure limits to harmful or toxic substances by excluding scientific studies for which raw data cannot be disclosed. Although the rule was due to take effect in January, it was vacated by a federal judge on 1 February.

The nonprofit organization Union of Concerned Scientists (UCS) documented 187 cases of political interference with science during Trump's four years. By comparison, the group counted 22 instances over Obama's eight years and 98 during George W. Bush's two terms.

Joel Clement, who catalogs episodes of political interference, was a high-ranking scientific career official in the Department of the Interior who had been working to assist Alaskan native communities in mitigating the impacts of climate change. Soon after Trump took office, he was reassigned to lead the department's office that collects royalties from oil and gas leases on federal lands. He resigned a few months after becoming a whistleblower and authoring a July 2017 op-ed in the *Washington Post*.

"It felt like being bullied in a schoolyard," Clement says. Political appointees in the agency had broken long-standing rules on reassigning senior career executives, he says, and had done so "in retaliation for my work telling them we've got to address these climate issues." He continues to work on Arctic issues as a senior fellow at Harvard University's Belfer Center for Science and International Affairs.

Jacob Carter worked on an EPA project to mitigate climate-change-caused flooding at the 1000 or so Superfund sites along the East Coast. Should a site be inundated by rising sea levels or heavy rains, toxic contaminants would leak into surrounding communities that are disproportionately communities of color and low income. Carter's research was aimed at assisting EPA site managers in determining the risk to particular cleanup sites and whether that risk warranted accelerating a cleanup or making

a site more resilient. Carter, whose contract with the EPA expired days after Trump took office, says his peer-reviewed work was buried by the agency.

A UCS analysis released in January said that from a peak of 11 647 in early 2017, the scientific workforce at the EPA had fallen by 672 positions by 2020. The Interior Department's Fish and Wildlife Service lost 231 jobs during that period, and the US Geological Survey had 150 fewer scientists. On the other hand, 91 scientist positions were added at NASA and 79 at NSF, according to the UCS.

Droegemeier disavows any part in political meddling. "I was never directly aware or involved in incidences of political interference in science. They happened at the agency level," he says. "I said in my confirmation testimony that science needs to speak in an unfettered way and scientific results should be as they are."

## Undoing the damage

Although the new administration rejoined the Paris Agreement on day one, reversing or rescinding all the Trump administration's environmental rules in such areas as clean air and wetlands could take years. "The Biden administration has a lot of digging out to do. I wouldn't trivialize that it's going to happen quickly," says Princeton's Moss. Adds CFR's Hill, "It takes time, it's complex, and it involves many experts to determine how to get back to where we were."

Trump's executive orders also can't always be reversed instantly by issuance of another order. "You've got to bring in lawyers to look at an order, you've got to agree on the right action, and you have to ensure it's an area that requires presidential attention," notes Hill.

Rejoining the Paris Agreement ensures that the US will be influential once again in the international response to the warming climate, says Lane. "But the world knows that in four years, it's possible someone will come in and go back to the dark ages," he warns. "They'll be hesitant to get too far out and assume we'll be a reliable partner for the next 20 years."

Myron Ebell of the libertarian Competitive Enterprise Institute sees another impediment to President Biden's climate change and environmental agenda. "The Biden administration will

be up against what the Obama administration was at the end of its term: They have a very skeptical Supreme Court." He points to the court's 5–4 overturning in 2015 of the Obama-era rule that set emissions restrictions on mercury and other toxic pollutants by power plants and the court's blocking by the same margin of Obama's Clean Power Plan in 2016. "We have a new and improved Supreme Court now," Ebell says, referring to the three conservative justices appointed by Trump.

Rebuilding the scientific workforce at the agencies also will take time. Many of the scientists who left the administration have moved on to other jobs, and federal hiring authorities are cumbersome, says Hill. "It's not like once somebody leaves, they can jump back into their position."

Droegemeier acknowledges much unfinished business. Maintaining global competitiveness will require figuring out how to quickly scale up newly developed technologies and bring them to commercialization, he says. That will require much stronger interactions be-

tween federal agencies, national laboratories, universities, and the private sector. "We learned from the pandemic that we can do things much faster and much more effectively in the midst of a crisis. Let's take those lessons learned and apply them to day-to-day business," he says.

Addressing competition from China will require far more than incremental increases to the agency budgets, warns Lane. "The idea that there are fields that are overfunded and we can just move money around, forget about that."

While expectations are high, Biden supporters see better times ahead. "Most scientists I talk to love the fact they can turn on the TV or radio in the morning and not have a feeling of dread at some anti-scientific proposal being floated or implemented by the administration," says Foster. He and Lane agree Biden's appointment of trusted experts, notably Eric Lander, who will be the first OSTP director with cabinet rank, sends a strong signal about the high value the president will have for science.

David Kramer **PT**

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