FORUM

Issues regularly receives numerous letters from readers responding to our articles. We print some of them here. A fuller collection can be found in our online Forum: https://issues.org/section/forum/.

GAIL J. HIGENELL, *Earth Reframed: The Seen and the Unseen,* 2023, commercial and hand-dyed cotton fabrics, heat-manipulated materials, embroidery floss, and a frame built from repurposed pine wood, 29 x 44.5 inches.

THE POLITICS OF WASTEWATER REUSE

In "Industrial Terroir Takes on the Yuck Factor" (*Issues*, Summer 2024), Christy Spackman describes clever attempts to overcome the prevailing challenge of public skepticism toward the prospect of potable water reuse.

The effects of infrastructure have long been recognized by urban historians as profound and path dependent, albeit indeterminate. In the case of water reuse, once the initial water and sewers systems are laid, the accompanying social, economic, and cultural institutions serve to entrench a commitment to waterborne sanitation systems materially, culturally, and politically. Thus, in the United States and elsewhere, the flush toilet and the treatment-based approach to managing water quality results in investment in water purification technologies and, ultimately, finding beneficial uses for wastewater. In this regard, the "treat, treat, and treat again" industrial terroir supports the reasonableness, acceptability, and inevitability of reusing wastewater for drinking water.

For boosters of potable water reuse, purity and security are key discursive concepts. At the molecular level, treatment processes remove all markers of "place" from water, but as soon as we change our scale, as Spackman does, we understand that urban drinking water is an intimate and embodied experience. Further, water is geopolitical. Water infrastructures are, in essence, social arrangements. The focus on the molecular scale provides little opportunity to consider the inevitable changes in social power that accompany this shift. Who gains, who suffers, and who pays for this change?

By adapting to existing infrastructure, including political commitment to flush toilets and the removal of pollutants

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FIERCE PLANETS

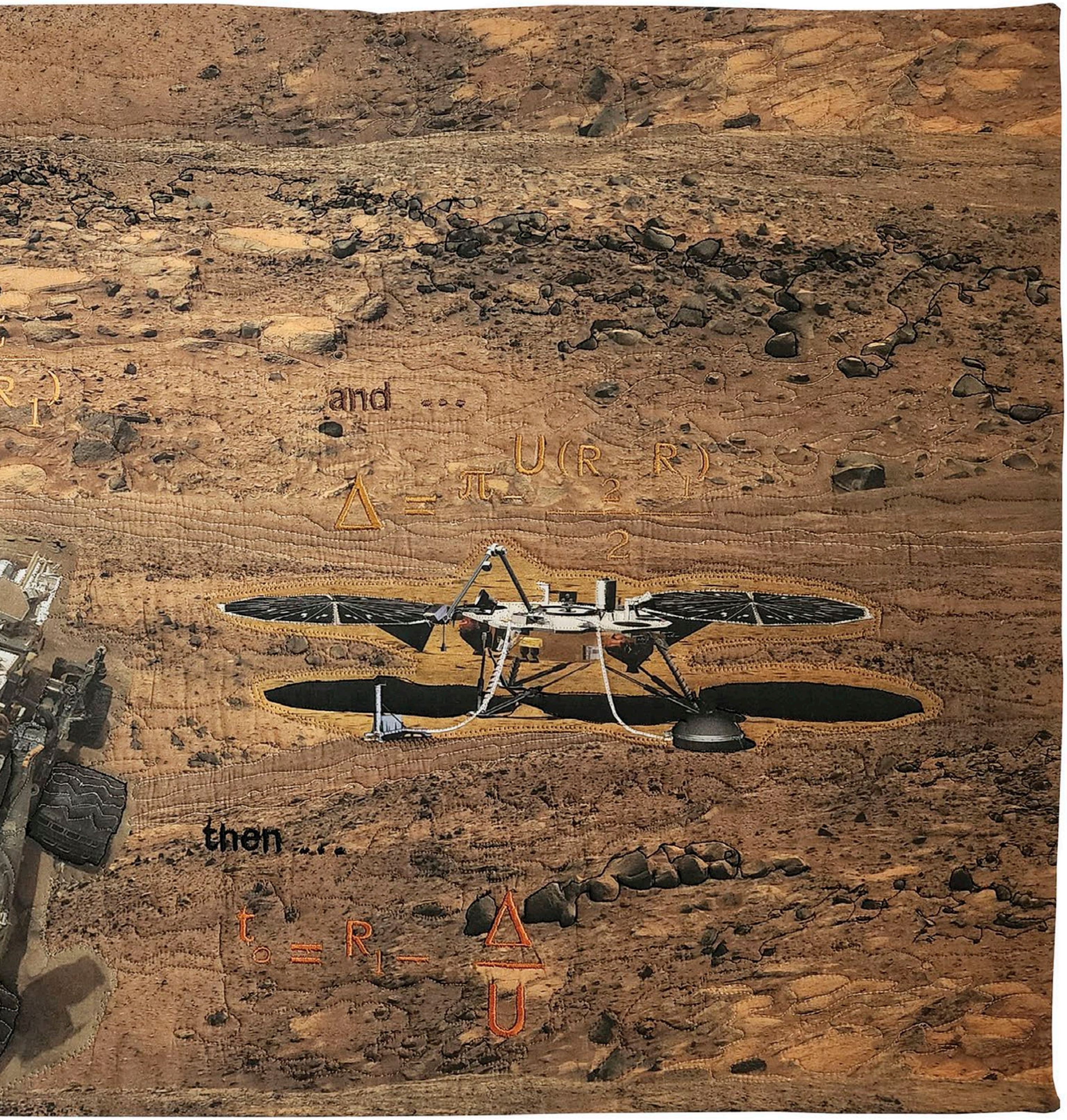
Exploring the cosmos through fiber art and planetary science

Iron snow, helium rain, and diamond icebergs might sound like science fiction, but they are real phenomena occurring within planets due to extreme heat and pressure. In their recent book, *What's Hidden Inside Planets*?, planetary scientist Sabine Stanley and science journalist John Wenz guide readers through the enigmatic realms beneath planetary surfaces. They delve into how the interiors of Earth and other planets are intricately linked to the formation and regulation of atmospheres, oceans, earthquakes, and volcanoes. The book and Stanley's research into these powerful forces inspired the artwork in the traveling exhibition *Fierce Planets*.

The juried exhibition is a collaboration between Studio Art Quilt Associates and the Johns Hopkins Wavelengths science communication program. *Fierce Planets* brings together work by artists from around the globe, each interpreting the mysteries of planets and space through fiber art. Their creations range from traditional quilts to fabric assemblages and soft sculptures, all inspired by Stanley's research. Out of nearly 200 works submitted, 42 were selected to be part of the exhibition.

Fierce Planets isn't just about aesthetics; it's about fostering a deeper understanding of and connection to the universe, inviting viewers to explore the beauty and complexity of planets through a unique lens.

Venues hosting the exhibition include the Exploratorium in San Francisco, California: December 14, 2023 (select pieces); Louisiana State University Museum of Art in Baton Rouge, Louisiana: April 18–September 8, 2024; New England Quilt Museum in Lowell, Massachusetts: January 15–May 10, 2025; and Dunedin Fine Art Center in Dunedin, Florida: June–August 2025.

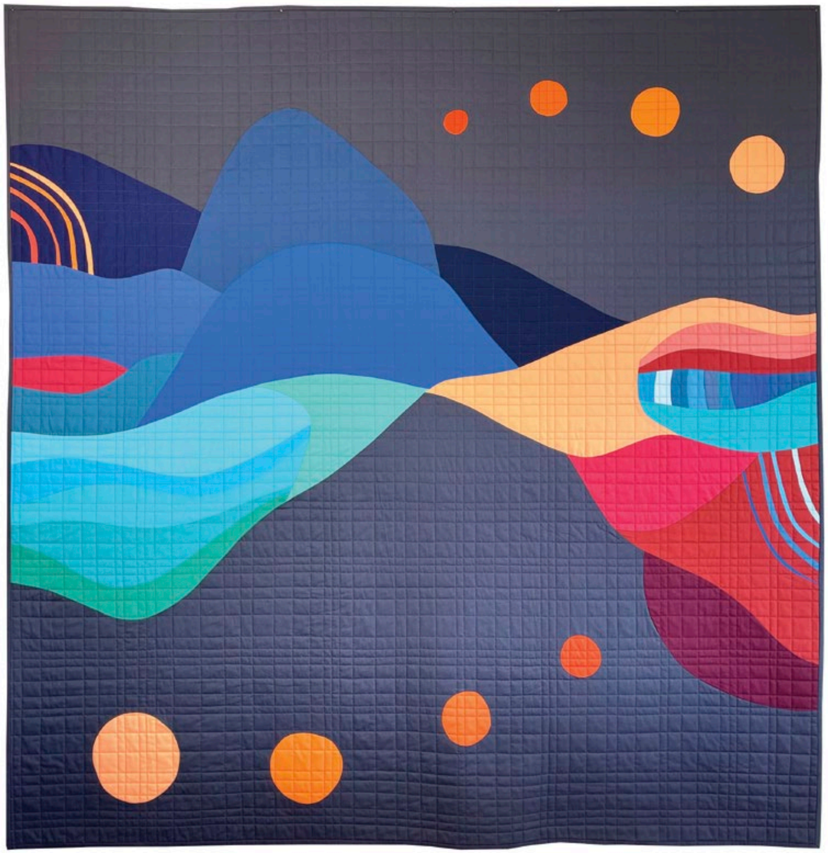


KATHLEEN DECKER, *Marsquake!,* 2023, cotton fabric, cotton batting, photos printed on fabric (image credit: JPL/NASA), cotton, silk, and polyester quilting thread, 25.5 x 29 inches.

via centralized wastewater treatment, engineers apply new tools and new procedures to move a finite amount of water through higher levels of treatment. As a result, highly treated wastewater is seen as a solution to many of the growing challenges of urban water scarcity in many regions. Although purported as radical reorganization of water governance (by Spackman and others), potable water reuse is an approach that minimally disrupts the fundamental infrastructure and inertia of large sociotechnical systems. In this case, innovative new technologies have been designed to retrofit and protect outdated infrastructures in a process the political scientist Langdon Winner described as "reverse adaptation." This preference to adapt to the established infrastructure has meant that alternative means of managing human bodily wastes have never realistically been considered.

The universal ideal of modern sanitation is not complete, nor is it necessarily stable. Cities across the globe are facing serious water, energy, and transportation challenges. The prospect of potable water reuse offers a unique opportunity to make connections, discover alternatives, and acknowledge that urban transition is inevitable. Water development aimed at providing greater water security with the least social disruption over the short term may be a maladaptation. The question is not solely if the public will accept that potable water reuse can be done safely, but if reuse will lend itself to a sustainable and just transition at the city and regional scale.

Kerri Jean Ormerod
Associate Professor, Department of Geography
University of Nevada, Reno



CAROLINA ONETO, *Imaginary Places IV,* 2023, cotton fabrics, cotton batting, threads for piecing and quilting, 56 x 55 inches.

In a seminal lecture in Dallas in 1984, which would later get published as *H_20 and the Waters of Forgetfulness*, the philosopher, priest, and social critic Ivan Illich argued for a separation of water and H_20. The latter, a modernist creation, was "stuff" produced by an industrial society and circulated through pipelines to deodorize and sanitize urban space. Devoid of social and spiritual meaning, H_20 was reduced to the odorless and tasteless substance we became familiar with in school textbooks, but perhaps rarely encountered in our everyday lives.

Christy Spackman makes it clear that the struggle between water and H_20 continues to animate contemporary concerns around "scarcity" and "reuse." The scientific and technological labor that transformed water into H_20 involved a two-step process. The first required the material reconstruction of water by removing "undesirable" salts, metals, and minerals, and purifying it by adding chlorine (and in many parts of the world "fortifying" it with fluoride). The second step involved reworking the sensorial and social script around H_20 and resocializing it into potable water.

The acceptability of direct potable reuse of wastewater has to negotiate this challenge of resocialization. Recycled wastewater has to regain its place in society. It has to shed the history of its recent defilement by illustrating that what is being used to produce beer is not just engineered H_20, but potable water.

Matter constitutes memory in water—where it has been (place), for how long (time). When we add and subtract matter in water, we reconstitute its relation to place and time. One might assume that since modern (and secular) water emerges out of a continual process of addition and subtraction, it should not be difficult to convince users to drink recycled water. The "yuck" factor that Spackman describes contradicts that logic. Technologies can materially reconstitute H_20 in myriad ways and claim it to be "just straight water," but to users water quality remains a product of history. The engineer can erase the material history of water, but the user will remember its past relationships with place and time. This shows up in Spackman's discussion of the humorous expression "poop beer," which refers to beer made with recycled water. Resocializing H_20 as water, therefore, requires not only reconstituting matter in water but also the users' memory of that water.

The author's lively essay illustrates the continued contest of competing imaginations around water in Arizona. I cannot but wonder as to how memories will be reconstituted in Flint, Michigan, or Jackson, Mississippi, where water has the color of lead and the odor of racism. As place forcefully asserts its presence in water in these sites, it reminds us that increasing demand for recycling wastewater for potable reuse will soon have to contend not only with matters of taste but also with concerns of justice.

Amitangshu Acharya
Lecturer, Water Governance
IHE Delft Institute for Water Education
The Netherlands

ANNE BELLAS, *Soleil et Lunes (Sun and Moons),* 2020, hand dyed, printed, machine pieced, machine quilted, cotton sateen, commercial fabrics, 46 x 36 inches.

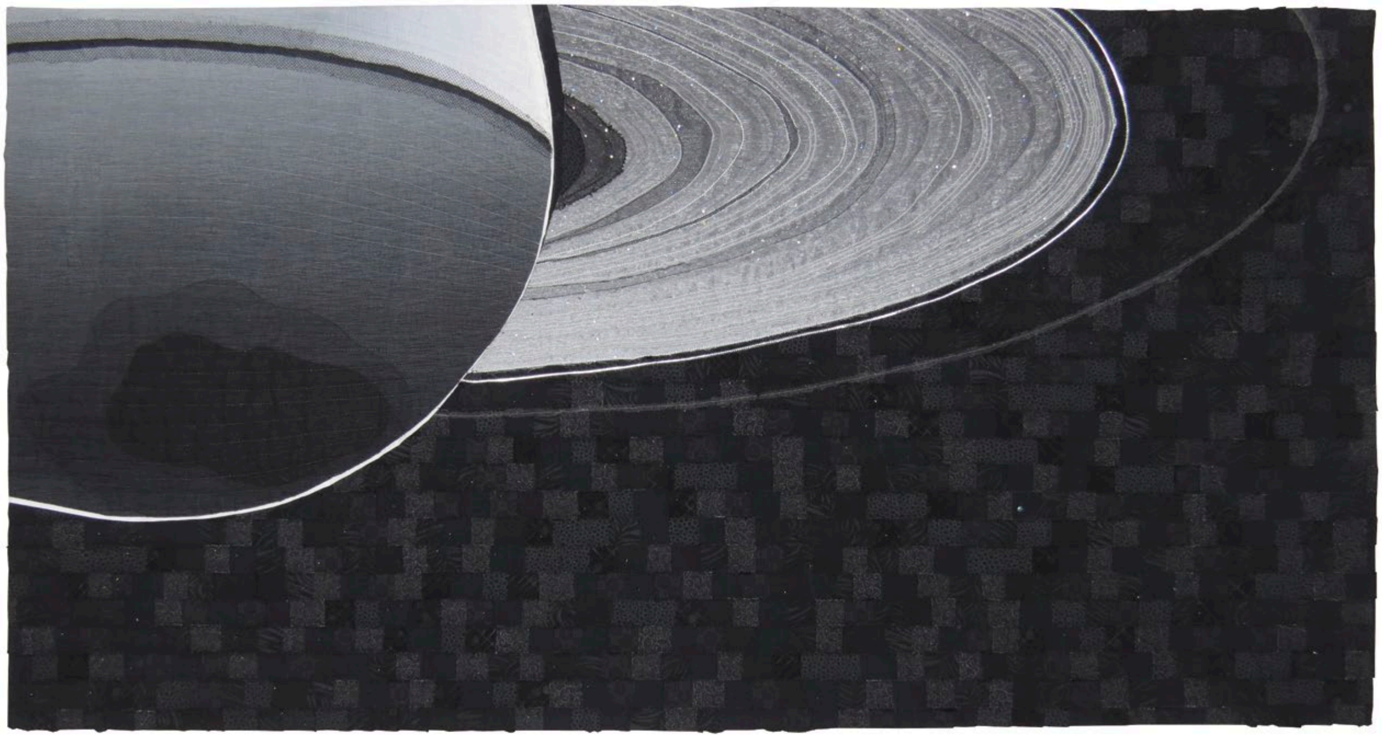
THE FUTURE OF FUSION

The Summer 2024 *Issues* addresses pressing topics in fusion energy development. In "What Can Fusion Energy Learn From Biotechnology?" Andrew W. Lo and Dennis G. Whyte highlight parallels between the evolution of these industries that offer bountiful benefits yet have faced challenges. As head of the Fusion Industry Association, I thank the authors for naming the FIA as the right venue for open, direct, and transparent communication about fusion's direction. They also make the critical point that the United States needs to foster a robust commercialization ecosystem that includes government research laboratories, universities, and private-sector fusion developers, as well as companies comprising the supply chains linking efforts.

We also agree with Michael Ford's statement in "A Public Path to Building a Star on Earth" that funding for fusion research must increase dramatically to meet the needs of both the scientific program and the needs of commercialization. Toward this aim, the FIA has submitted a proposal to both Congress and the US Department of Energy for $3 billion in supplemental funding to accelerate fusion commercialization and build fusion energy infrastructure.

As part of Ford's proposed path, he calls for a "coordinated plan for public and private funding." But I would add a caveat. The fusion community already has made more plans than it has taken action on. Instead, now it is time to execute the plans already agreed upon. The fusion community delivered a comprehensive Long Range Plan in early 2021. The plan, now being updated to reflect advances in fusion technology and ambition since then, acknowledged that without significant increases in funding, DOE would face difficult choices that could reduce plasma physics funding in some areas, in order to provide more robust support for more commercially relevant programs such as materials science, fuel cycles, and public-private partnerships. Without a strong growth in funding across the board, prioritization is necessary.

We agree that DOE's role is to support fundamental research and enable the growth of the commercialization ecosystem without skewing the competitive landscape—and that means the national labs and companies should



DOLORES MILLER, *Pale Blue Dot 2,* 2023, commercial cottons, polyester sheers and netting, polyester and hologram mylar threads, metallic foil, 19 x 36 inches.

avoid directly competing. It also means that DOE should realign its efforts to appropriately fund both commercially relevant programs and the scientific research and development that is needed to build fusion demonstrations. It is time for DOE to treat fusion as an energy source, not a science project, and so it is appropriate to begin the transition to an applied energy office.

Finally, both articles highlight the importance of building trust to support public acceptance. The fusion industry recognizes that engagement with the public, stakeholders, and the broader scientific community is essential to the successful development and deployment of fusion energy. In line with Lo and Whyte's recommendations, the FIA aims to ensure that all these groups receive timely, clear, and transparent information. Among other efforts, we will communicate about when companies reach milestones for fusion's progress, providing easily understandable, tangible proof points for policymakers, investors, and the public.

The fusion community is moving forward at speed to be ready for the next phase: focused execution to bring fusion energy to market. The FIA looks forward to collaborating across public and private sectors to ensure that fusion achieves its potential as a clean, limitless energy source.

Andrew Holland
Chief Executive Officer
Fusion Industry Association

Michael Ford effectively highlights the critical importance of maintaining public funding for fusion research, given the technology's current stage of development. Indeed, the phrase "building a star" arguably understates the task at hand.

In the wake of Lawrence Livermore National Laboratory's repeated achievement of "ignition" using inertial fusion technology—that is, the production of more energy from a fusion reaction then needed to create it—an increasingly common refrain holds that commercializing fusion is no longer a physics problem, but an engineering one. This downplays the complexity and difficulty of fusion. As Ford rightly points out, there are still significant unknowns regarding which approaches will prove optimal or even viable. The timeline for achieving commercial fusion energy is uncertain, underscoring the necessity for continued fundamental research and development. This foundational work is essential to unravel the complexities of plasma physics and materials science that underpin fusion technology.

The 2022 Inertial Fusion Energy (IFE) Basic Research Needs effort, organized under the auspices of the Fusion Energy Sciences program at the US Department of Energy Office of Science, laid out the core innovations that must be advanced to make IFE a reality and attempted to evaluate technical readiness levels of the key IFE technologies to guide where investment is needed. Today, none of these have matured to the technical readiness levels necessary for use in a pilot power plant, and physics questions abound as we strive to mature them. Because of this, funding for fundamental R&D must remain paramount in the fusion effort, despite the ambitious timelines set forth by the fusion start-up community.

Similar efforts to identify core science and technology gaps should be undertaken for the broader fusion effort; at this early stage, an all-of-the-above approach is called for. Roadmaps and clear metrics resulting from such efforts should be used to hold the private and public sectors accountable and to strategically choose among possible technological options to sustain the value of public funds.

Fusion is not just a scientific endeavor; it is a strategic asset for US competitiveness and national power. The public sector has a pivotal role in stewarding this technology to ensure it aligns with national interests. Developing public-sector anchor facilities, safeguarding intellectual property, and supporting the supply chain are crucial steps in bolstering the nation's know-how and economic strength. Public investment in these areas will help secure a leadership position in the global fusion landscape.

While the United States spends less than some other fusion aspirants, including China, the achievement of fusion ignition has put it in pole position. That lead is hard-won, resulting from decades of public investment and innovation. It can be easily lost.

We are convinced that a world powered by fusion energy is achievable. It is not a question of time, but one of resources and political will. Sustained investment in a foundation of science and technology will bring this future into focus.

Tammy Ma
Lead, Inertial Fusion Energy Institutional Initiative
Lawrence Livermore National Laboratory

DIANNE FIRTH, *Saturn Observed,* 2023, wool batting, polyester net, polyester thread, 29.5 x 29.5 inches.

Andrew W. Lo and Dennis G. Whyte draw four specific lessons for fusion from the biotechnology industry. The exhortation to "standardize milestones" is particularly important. The authors suggest a consortium for identifying the right milestones, but it remains critical to explore the unique aspects of fusion in contrast with biotechnology and other fields to find a model that will work.

Unlike the Food and Drug Administration, fusion's US regulator, the Nuclear Regulatory Commission, does not have a mandate to regulate efficacy. Rather, the NRC's mission relates to safety, common defense, and environmental protection. This sensibly reflects the fact that market forces alone are sufficient to ensure that fusion works (i.e., it generates useful energy economically). This presents an underappreciated opportunity for the fusion industry to take advantage of the benefits of standardized milestones without the expensive and time-consuming formality that the FDA correctly imposes on the biotechnology industry.

Consulting firms that evaluate the claims of fusion companies for investors are appearing as a result of these market forces. Though useful, consultants and their reports don't provide the structural benefits that standardized milestones could bring to the entire industry in the form of on- and off-ramps for different groups of investors and scales of capital as Lo and Whyte discuss.

Because of this missing piece, some fusion investors and fusion companies themselves are clamoring for such a set of standardized milestones. Some have emerged organically. The Department of Energy's Milestone-Based Fusion Development Program issues payments based on the completion of benchmarks proposed by the companies themselves and negotiated between the companies and DOE. Most recently, Bob Mumgaard, CEO of Commonwealth Fusion Systems, published an open letter, titled "Building Trust in Fusion Energy," that lays out six milestones on the path to fusion energy, many of which are similar to milestones for funding in the ARPA-E

Breakthroughs Enabling Thermonuclear-fusion Energy (BETHE) program.

However, these are not the right entities to independently develop and arbitrate standardized milestones for fusion. Although DOE is equipped to judge whether a milestone has been completed, relying on DOE (or NRC) for broader oversight is to give up the advantage that fusion has to manage milestones in a more lightweight and nimble way outside of government. Nor are fusion companies, investors, or the Fusion Industry Association appropriate organizations for this job, for obvious conflict-of-interest reasons. Instead, a nongovernmental, independent rating organization is needed.

There are lessons here from the finance industry. Agencies such as Moody's and Fitch Ratings play an important role in providing information to investors about the creditworthiness of companies and the likelihood that bonds will be repaid. However, their business models rely on payments from the entities being rated, and the review process is not especially transparent, both of which were factors that led to the 2008 financial crisis. Fusion could do better by developing a different business model that decouples the ratings from payments made by the entities being rated and by emphasizing the importance of publishing data on milestone completion in peer-reviewed journals.

Identifying milestones that are meaningfully applicable to all approaches to fusion energy, an objective arbiter of those milestones, and an appropriate rating system is an important next step in the development of the fusion energy ecosystem. This should be an iterative process involving companies, investors, and academia. Success will require creativity in balancing competing interests, and an evenhanded assessment of the science, engineering, economics, and social-acceptance challenges facing the nascent fusion energy industry.

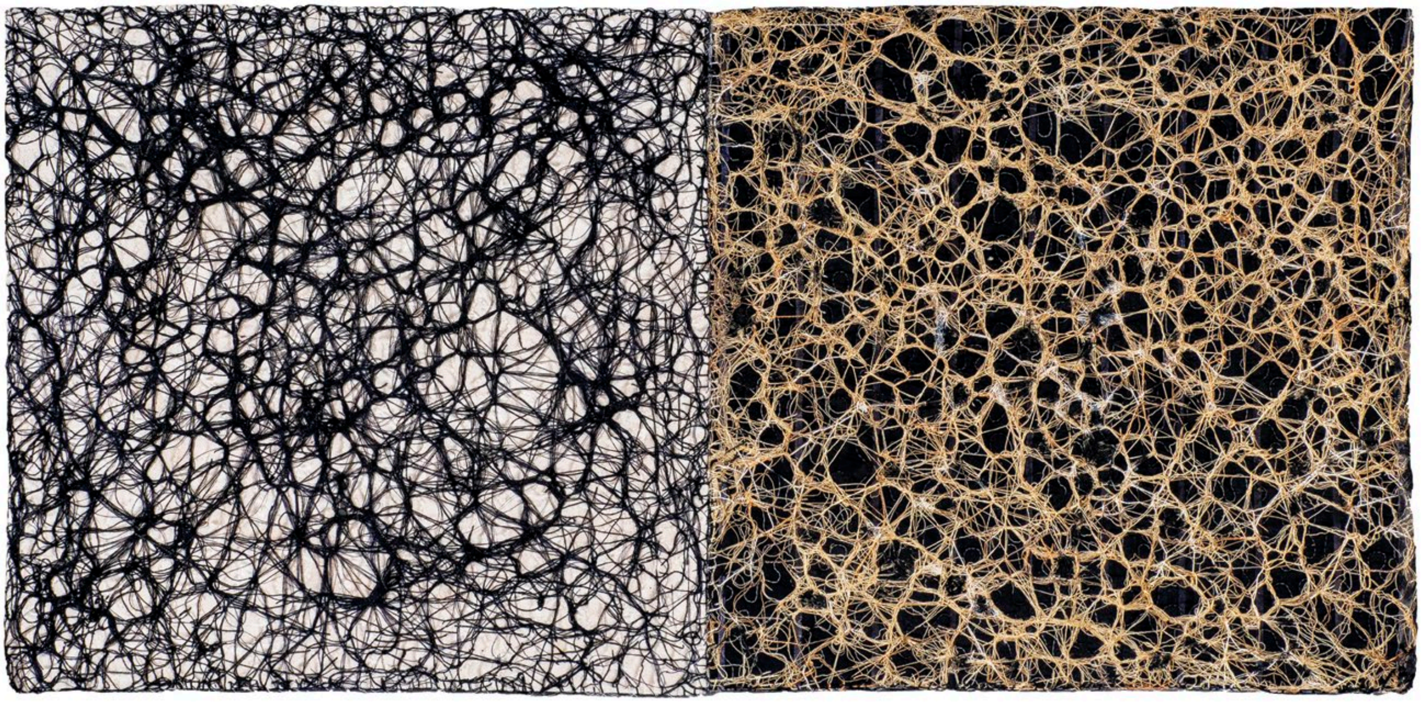
Sam Wurzel
Fusion Energy Base

MIEKO WASHIO, *Cosmos,* 2020, appliquéd, machine quilted, hand quilted, hand embroidered, cotton, satin, yarn, 64 x 59 inches.

HOPE FOR HYDROGEN

In "Moving Beyond the Hype on Hydrogen" (*Issues*, Summer 2024), Valerie J. Karplus and M. Granger Morgan provide an excellent assessment of hydrogen's advantages and significant barriers to market formation. Toyota has more than 30 years of experience with all phases of the hype cycle for hydrogen—innovation, inflated expectations, disillusionment, and enlightenment.

Toyota began developing its hydrogen-powered fuel cell vehicles in 1992, one year after Sony commercialized the lithium-ion battery. Sales of the first hydrogen passenger car, the Mirai, launched in 2014, with the second generation in 2021. Over those 30 years, we saw the initial innovations in fuel cells dramatically improve



SHIN-HEE CHIN, *Cosmic Threads: Connections of Neurons and Galaxies,* 2023, recycled blankets, perle cotton threads, polyester threads, 21.5 x 43 inches.

in unexpected ways. During the same period, we also watched lithium-ion batteries grow into the clear leader in the race to decarbonize passenger cars.

Despite the technical success of the Mirai, the vehicle has struggled in the marketplace due to the difficulties of hydrogen supply and fueling infrastructure. The challenges continue, with high prices for hydrogen at the pump and fuel stations closing. Despite headwinds, at Toyota we find ourselves asking the same question as the article: "Is hydrogen's long-forecast—and long-hyped—future [as a fuel for transportation] finally here?" There are reasons to be hopeful.

Transportation encompasses more than passenger cars, with about 25% of transportation carbon emissions coming from medium- and heavy-duty commercial transport. While hydrogen will compete with battery electrics in commercial vehicles, both have significant infrastructure challenges. Battery electrics don't have the same advantages in large vehicles with high mileage as they do for passenger cars. The best choice remains unclear.

Not long ago, the technical barriers for fuel cells in large commercial vehicles seemed insurmountable. But the technology is here today. The key barriers remain in the hydrogen ecosystem: achieving low-cost production, sufficient distribution, and matching of supply and demand. The US hydrogen hubs are an exciting idea for creating a useful hydrogen market, tackling production and multisector consumption in a coordinated way. Initiatives such as the hubs are important to advance the portfolio of hydrogen applications beyond transportation.

The success of hydrogen in commercial transport depends on the key question the article asks: "Which users of fossil fuels must bear the costs?" Companies that operate commercial vehicles are sensitive to the total cost of ownership. Diesel is a low-cost, energy-dense fuel with an existing infrastructure. While the low cost makes diesel difficult to displace, we must also account for all societal costs. Diesel trucks are large emitters of particulate matter and pollutants, which have severe impacts on health in many communities.

Karplus and Morgan place a 70:30 bet that hydrogen "will become an important part of the portfolio of technologies" for decarbonization. Portfolio is a key word here, and we need to explore all options for commercial transport including battery-electrics, better fuels, and better fuel economy. I don't know if the 70:30 odds for hydrogen are a good bet or not. But at Toyota, we're aggressively developing the technologies to try to tilt those odds toward success as strongly as we can.

Brian Storey
Vice President of Energy & Materials
Toyota Research Institute

PREPARING THE NEXT GENERATION OF NUCLEAR ENGINEERS

In "Educating Engineers for a New Nuclear Age" (*Issues*, Summer 2024), Aditi Verma, Katie Snyder, and Shanna Daly's vision closely aligns with recent sociotechnical advancements, particularly in the realm of artificial intelligence-powered simulations. Recent research has demonstrated the potential of virtual reality (VR), augmented reality (AR), and other immersive technologies to bridge the gap between technical knowledge and real-world application in engineering education. Studies indicate that VR and AR can significantly enhance spatial understanding and conceptual learning in complex engineering systems.

These technologies allow students to interact with virtual models of nuclear facilities, providing a safe and cost-effective way to gain hands-on experience. The simulations can adapt in real-time to student interactions, offering a more realistic and nuanced understanding of how technical decisions impact social and environmental factors. This fits perfectly with the authors' goal of preparing engineers to collaborate effectively with communities and consider broader societal implications.

My recent work on modernizing education for the nuclear power industry underscores several key points that complement the authors' vision. First is the need for rapid technological advancements in training methodologies to keep pace with industry evolution. The nuclear industry is facing a critical juncture where modernizing education and training is essential. The need for cost-effective approaches in training is paramount, especially with a projected increase in the number of nuclear plants and employees. This expansion necessitates scalable and efficient training methods that can accommodate a growing workforce while maintaining high standards of safety and competence.

Second is the importance of addressing emerging demographic shifts and knowledge transfer challenges, and the critical role of fostering a continuous improvement culture within engineering education. As experienced professionals retire, there is an urgent need to transfer knowledge to the next generation of nuclear engineers and technicians. Interactive e-learning environments and mobile accessibility can facilitate this knowledge transfer, making it more engaging and accessible to younger professionals and directly supporting the goal of creating more empathetic and ethically engaged engineers.

Third is the critical need to foster a continuous improvement culture within engineering education. The changing work environment demands adaptable training solutions. The integration of VR and AR technologies in training programs can provide immersive, hands-on experiences even in remote learning settings. This approach enhances the learning experience and improves safety by allowing trainees to practice in risk-free virtual environments.

Even as cutting-edge technologies are reshaping training methodologies, offering a versatile tool kit to optimize effectiveness and stay at the forefront of industry standards, work remains. Key areas to explore include interactive learning approaches and e-learning environments, VR and AR simulations for immersive experiences, AI-powered simulations for realism and adaptability, precision learning technologies for enhanced effectiveness, personalized skill development paths and adaptive learning, gamification for engagement, dynamic learning analytics and predictive analytics for proactive enhancement, and natural language processing to enhance instant support.

By applying the lessons we've already learned and the knowledge future studies will certainly bring, and combining these advancements with the authors' community-centered, ethically driven approach, we can truly prepare the next generation of nuclear engineers. This holistic approach to education and training will enhance the industry's safety and efficiency and contribute to its long-term sustainability and public acceptance.

Olivia M. Blackmon
Director, ORAU Partnership for Nuclear Energy
Oak Ridge Associated Universities

THE POLITICS OF RECOGNITION

As I was reading Guru Madhavan's "Living in Viele's World" (*Issues*, Summer 2024), my thoughts turned to studies of occupational prestige—in other words, the perception that some types of work are more deserving of admiration and respect. Historians and social scientists who examine occupational prestige pursue lines of inquiry that spread in many directions, including the implications for individual self-worth, differences in salaries, longitudinal trends for the American labor force, and more.

In his eloquent essay, Madhavan demonstrates the importance of seeing the actions of two elites in nineteenth-century New York, Egbert Ludovicus Viele and Frederick Law Olmsted, within a social scientific setting. Although these men brought different technical points of view to the design of crucial elements of New York's infrastructure, Madhavan's point is that we will understand their legacies more deeply if we see their work as part of a broader contest for authority and prestige.

Madhavan's invocation of the politics of recognition—a concept with its own rich scholarly tradition—is a compelling way to think about engineering and society. In particular, it expands our conceptual language for considering the normative consequences of infrastructural decisions, including the ways that these decisions can either facilitate or inhibit equity and human flourishing.

In our 2020 book, *The Innovation Delusion*, Lee Vinsel and I argued that the trendy preoccupation with innovation, and the resulting elevated prestige of innovators, carries steep societal costs. These costs include the neglect of maintenance (made familiar with the dismal grades regularly registered in the American Society of Civil Engineers' Infrastructure Report Card) as well as diminished prestige for the people we called maintainers—the essential workers who care for the sick, repair broken machines, and keep the material and social foundations of modern society in good working order. Vinsel and I challenged society to reckon with the caste-like structures that keep janitors, mechanics, plumbers, and nurses subordinate to other professionals. This line of thinking also sharpens our understanding of the stakes for the present and future, namely, that many young people self-select into occupations that are seen as prestigious and forego career paths that lack glamor or respect.

As a result, there is an oversupply of young people who want to get into "tech," even as the giants of Silicon Valley continue to lay off workers so that they can keep wages low and stock prices high. At the same time, there is an undersupply of young people who want to work in the skilled trades, where there are national shortages and good careers for people who want to work hard, uplift their communities, and care for the needs of their fellow residents. Closer attention to the politics of recognition in engineering—indeed in all occupations—can help Americans understand how we arrived at our present state, overcome some of our elitist prejudices, and recalibrate the relationship between occupational prestige and the workforce that the nation actually needs.

Andrew L. Russell
Provost
SUNY Polytechnic Institute

GENEVIÈVE ATTINGER, *The Improbable Modeling,* 2023; cotton; plastic; cardboard (book cover inner frame); cotton strap with metal buckle; metallic, polyester, and cotton embroidery threads; 14.5 x 14 x 14 inches.

SECOND-ORDER EFFECTS OF ARTIFICIAL INTELLIGENCE

In "Governing AI With Intelligence" (*Issues*, Summer 2024), Urs Gasser provides an insightful survey on regulating artificial intelligence during a time of expanding development of a technology that has both tremendous upside potential but also downside risk. His article should prove especially valuable for policymakers faced with making critical decisions in a rapidly changing and complex technological landscape. And while it is difficult enough to make decisions based on the direct consequences of AI technologies, we're now beginning to understand and experience some second-order effects of AI that will need to be considered.

Two examples may prove illustrating. Focusing on generative AI, we've witnessed over the past decade or so rapid development and scaling of the transformer architecture and diffusion models that have revolutionized how we generate content—text, images, software, and more. Applications based on these developments (e.g., ChatGPT, Copilot, Midjourney, Stable Diffusion) have become commonplace, used by millions of people every day. Much has been observed about increases in worker productivity as a consequence of using generative AI, and indeed there are now numerous careful empirical studies demonstrating positive effects to productivity in, for example, writing, software development, and customer service. But as worker productivity goes up, will there be reduced need for today's quantity of workers? Indeed, the investment firm Goldman Sachs has estimated that 300 million jobs could be lost or diminished by AI technology. The company goes on to estimate that 25% of current work tasks could be automated by AI, with particularly high exposures in administrative and legal positions. Still, the company also points out that workforce displacement due to automation has historically been offset by the creation of new jobs following technological innovation and that new jobs are created that actually account for employment growth in the long run.

A second example relates to AI energy consumption. As generative AI technologies and applications scale with more and more content being generated, we are learning more about the energy that is consumed in training the models and in generating the new content. From a global energy consumption view, one estimate holds that by 2027 the AI sector could consume as much energy as a small country (e.g., the Netherlands)—potentially representing a half a percent of global energy consumption by then. Taking a more granular view, researchers have reported that generating a single image based on a powerful AI model uses as much energy as it does to charge an iPhone, and that a single ChatGPT query consumes nearly as much energy as 10 Google searches. Here again there may be some good news, as it may well be possible to use AI to come up with ways to reduce global energy usage that more than makes up for the increased energy usage need to power modern AI.

As use of AI expands, these and other second-order (and higher) effects will likely prove increasingly important to consider as we work to develop policies that lead to responsible governance of this critical technology.

Frederick R. Chang
Professor Emeritus, Department of Computer Science
Southern Methodist University

LISA FLOWERS ROSS, *Titan Swath,* 2023, fabrics hand-dyed by the artist, yarn, thread, 64 x 26.5 inches.

CONSIDERING "COMMUNITY"

In "Bringing Communities In, Achieving AI for All" (*Issues*, Summer 2024), Shobita Parthasarathy and Jared Katzman's call for making community concerns the focus of meaningful AI development is important and timely. In particular, their emphasis on the role of universities in this effort rings true to me. In fact, I would argue that we—university educators and scholars who have access to resources and power—have a responsibility to consider what technological innovation and progress mean for how we envision our collective futures. We can leverage that responsibility to address the issue that "community" remains a vague (albeit en vogue) term. When we say community, we must specify who we mean, who is convening that community, and in what way.

A core community in the world of (higher) education and in the academic profession is the student body. Today, education is conditioned on the enrollment of students in technology systems, increasingly those that are artificial intelligence-enabled: learning analytics platforms, classroom surveillance technology, proctoring software, automated plagiarism detectors, college admissions algorithms, predictive student advising software, and more. Students are constantly surveilled and have no way of knowing about or refusing to get enrolled in AI systems—even though the pervasiveness of large-scale data collection and predictive analytics can affect their lives far in the future. At the same time, student power in the United States has been rolled back significantly over the past three decades. As a highly affected and often marginalized community in the university setting, students are structurally and culturally excluded from having a say about AI, because they generally have no say, regardless of how well they are organized *as a community*.

This tale holds a lesson: when we ask for communities to be brought in, we must also ask under what conditions. I profoundly agree that regulators play a crucial role in ensuring equity in AI, in all the important ways that Parthasarathy and Katzman describe. But I also note that engaging with constituents comes naturally to politicians and civil servants. It doesn't to industry leaders, including leaders in the tech industry or in education. As educators, we can help change that. In the classroom, we can work toward the socially committed AI research that the authors place at the heart of equitable AI. Adjacent and outside of the classroom, we can support our local community of students in organizing around technology and policy issues as they pertain to their immediate educational environment. And we can help them work to establish structures and processes that institutionalize student power—or community power—in the context of technology governance. One such structure is the idea of a student technology council, a small group of students that represents the student body on positions about campus technology and governance and that actively participates in administrative decisions on technology procurement and implementation. This may have a signaling effect to AI vendors whose biggest clients are large educational institutions.

We have a long way to go from idea to community-led deliberation and implementation. But thinking about student-driven governance of AI provides an opportunity to create more permanent structures around community engagement on AI that push beyond individual projects and allow us to get very concrete on community needs and desires.

Mona Sloane
Assistant Professor of Data Science and Media Studies
University of Virginia

CROSS-BORDER COLLABORATIONS

In "A Binational Journey Toward Sustainability" (*Issues*, Summer 2024), Christopher A. Scott, Constantino Macías Garcia, Natalia Martínez-Tagüeña, Thomas F. Thornton, and Heather Kreidler highlight the critical role of partnerships in mobilizing the knowledge, action, and resources to advance sustainability pathways for the US-Mexico border region. The authors illustrate how partnerships enable trust building, resilience, and adaptability in a region often characterized as fraught with conflict and social-ecological challenges. Yet partnerships also need support and recognition to thrive. In the binational region, the technical expertise, communication and physical infrastructure, and administrative processes can vary widely across private, civil society, and governmental organizations, and asymmetries can foster competition rather than collaboration.

To leverage the existing organizational capacities, there is a need for investment in cross-border and within-country organizational networks. Such investment could enable organizations to autonomously develop the technical capacities and deepen their relations of trust and collaboration in the contested and highly dynamic binational space. Networks of boundary-spanning institutions and organizations—literally spanning the international border, but also bridging science-policy, citizen-government, Indigenous-settler, private-public divides—are increasingly critical.

In a different region of the world, through the Accelerating Adaptation via Meso-Level Integration (ACAMI) initiative in sub-Saharan Africa, we are exploring what makes partnerships of organizations effective in enabling climate change adaptation for small-scale agricultural producers. We focus on "meso-level organizations" that individually and collectively channel material resources, knowledge, finance, and experience between macro-level actors (national governments, international organizations) and local-level beneficiaries. As in the US-Mexico border region, these meso-level organizations demonstrate innovative practices, novel interventions, and valuable experiences for sustainability transformations. They also face constraints: they often lack the time, flexibility, and capacity to retrain and pivot to embrace emergent and evolving challenges in the way they know is most appropriate. Networks of organizations that enable cross-organization learning rarely receive funding from the international community, and are rarely prioritized in national policy efforts.

Findings from the ACAMI initiative suggest that there is a need for investments in the organizational landscape to enable existing and new partnerships to thrive as sustainability challenges evolve. Scaling success requires recognizing the role of organizational networks in producing, synthesizing, and sharing knowledge; efficiently leveraging finance; building capacity across organizations; and influencing policy. Networks can enable the specialization and expertise of some organizations to serve others, reducing the barriers to engage with the frontiers of sustainability science through state-of-the-art data analytics, leading-edge system modeling and knowledge integration, and innovative and ethical collaborative frameworks. More successful networks can strategically manage uncertainty by leveraging complementary member resources and enabling less powerful organizations to contribute. Attention to power asymmetries and alignment of multiple forms of knowledge inherent in sustainability transformations is fundamental. As organizations, their partnerships, and networks assume larger roles in the sustainability space, they also must be accountable to the communities that support them through transparent processes of monitoring and evaluation. Pursuing sustainability goals is thus just as much about complexity in the organizational landscape as it is about the social-ecological challenges of critical regions.

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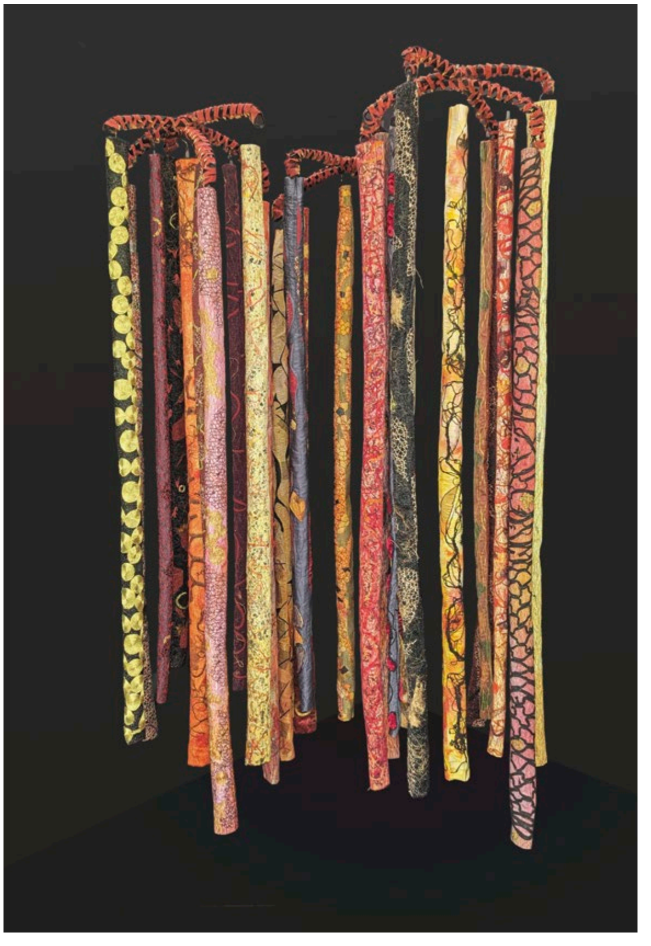
MAKING IMPACT COUNT

In "What We Talk About When We Talk About Impact" (*Issues*, Summer 2024), David H. Guston discusses the challenges in defining, measuring, capturing, and demonstrating the impacts associated with research and scholarly activities at institutions of higher education. After highlighting numerous efforts aimed at broadening socially impactful research, he concludes that much more needs to be done to expand the institutions' reward and incentive systems to encompass these varied forms of impact.

At the US National Science Foundation, we are pleased to contribute to this transformational change through a range of new initiatives, the most significant being the establishment of a new directorate—the agency's first in more than three decades. The Technology, Innovation and Partnerships (TIP) directorate, which was authorized by Congress in the CHIPS and Science Act of 2022, aims to accelerate technology development and translation, grow a new American innovation base for the mid-twenty-first century, and nurture a workforce of researchers, practitioners, technicians, entrepreneurs, and educators across all fields of science, technology, and engineering. TIP was specifically established to help reestablish the nation's standing in key technology areas for decades to come.

To achieve this mission, TIP is both enhancing and scaling existing programs—such as the NSF Small Business Innovation Research (SBIR)/Small Business Technology Transfer (STTR), Innovation Corps (I-Corps), and Convergence Accelerator programs—and initiating new activities designed to support capacity-building, use-inspired and translational research, economic growth and job creation, and practical experiences to prepare all Americans for these jobs. For example, the Accelerating Research Translation (ART) program specifically targets building and strengthening the underlying infrastructure for technology transfer at institutions of higher learning, seeking to catalyze a culture devoted to creating and enhancing economic and societal impacts. It requires a diverse set of stakeholders, including senior leadership, technology transfer offices, faculty, industry, nonprofits, and investors, to work together.



CLAIRE PASSMORE, *Hot Stuff,* 2023, cotton, silk, velvet, felt, tulle, nonwoven fabrics, threads, wool, continuous zip, pvc, fiber filling, dye, acrylic and enamel paint, plastic bottles, gold leaf, mica powder, glue, steel wire, 92.5 x 53 x 49 inches.

The NSF Regional Innovation Engines program similarly encourages cross-sector partnerships to harness a region's unique strengths and ultimately position it as a national and world leader in one or more key technology areas. And the NSF Experiential Learning in Emerging and Novel Technologies (ExLENT) program invests in regional cohorts of internships and apprenticeships.

These initiatives all require educational institutions and others to go beyond historic measures of impact, notably papers and conference proceedings, and take into account a range of practical quantitative and qualitative data such as invention disclosures, patents, licenses, revenues, start-ups established and acquired, talent trained in degree and certificate programs, and so on.

At a moment of intense global competition, the United States faces consequential decisions that will shape the evolution of its innovation enterprise—the envy of the world. We must continue to lead in curiosity-driven, foundational science, but we must also accelerate use-inspired and translational research. To do this well, we must promote a culture at higher-education institutions and other research organizations that not only acknowledges and rewards historic measures of success, but goes much further in welcoming tangible solutions for pressing real-world challenges in communities across the nation.

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