FORUM

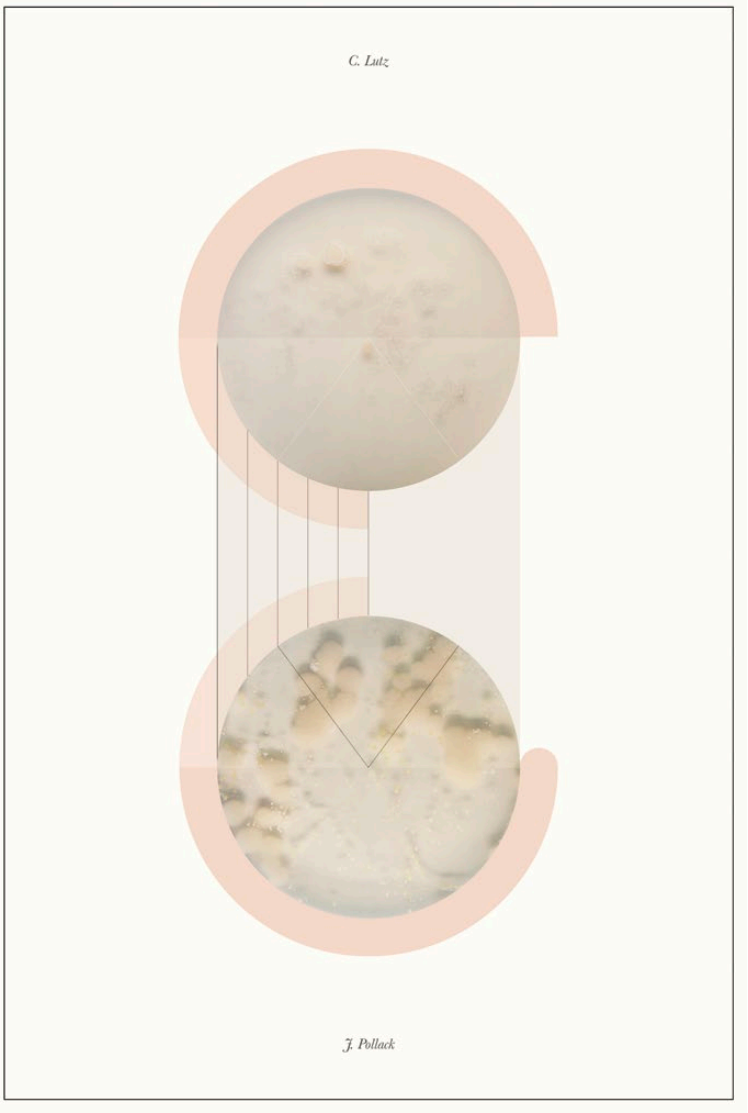
Issues regularly receives numerous letters from readers responding to our articles. We print some of them here. A complete collection can be found in our online Forum: https://issues.org/section/forum/.

FORKS IN THE ROAD TO SUSTAINABLE CHEMISTRY

In "A Road Map for Sustainable Chemistry" (*Issues*, Winter 2024), Joel Tickner and Ben Dunham convincingly argue that coordinated government action involving all federal funding agencies is needed for realizing the goal of a sustainable chemical industry that eliminates adverse impacts on the environment and human health. But any road map should be examined to make sure it heads us in the right direction.

At the outset, it is important to clear misinterpretations about the definition of sustainable chemistry stated in the *Sustainable Chemistry Report* the authors examine. They opine that the definition is "too permissive in failing to exclude activities that create risks to human health and environment." On the contrary, the definition is quite clear in including only processes and products that "do not adversely impact human health and the environment" across the overall life cycle. Further, the report's conclusions align with the United Nations Sustainable Development Goals, against which progress and impacts of sustainable chemistry and technologies are often assessed.

The nation's planned transition in the energy sector toward net-zero emissions of carbon dioxide, spurred by the passage of several congressional acts during the Biden administration, is likely to cause major shifts in many industry sectors. While the exact nature of these shifts and their ramifications are difficult to predict, it is nevertheless vital to consider them in road-mapping efforts aimed at an effective transition to a sustainable chemical industry. Although some of these shifts could be detrimental to one industry sector, they could give rise to entirely new and sustainable industry sectors.

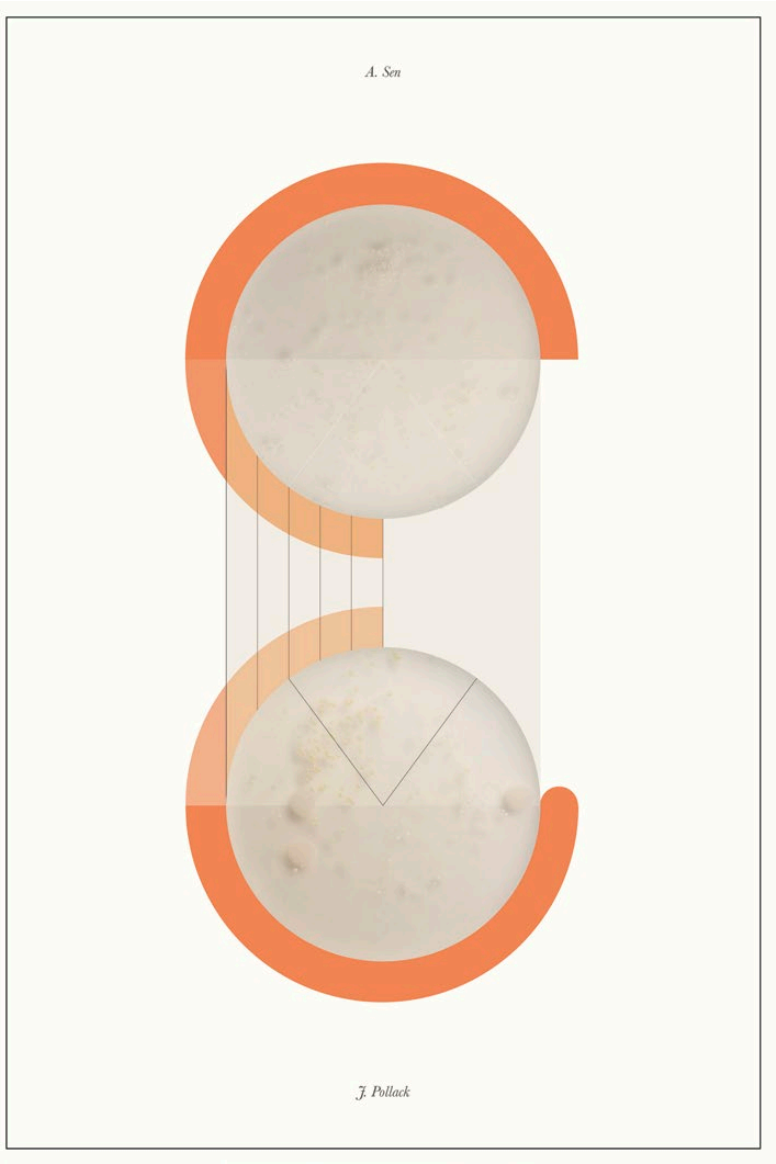


JULIA POLLACK, *In Fragments No Longer: Claudia Lutz and Julia Pollack,* 2023, inkjet print, 24 x 36 inches.

As an example, as consumers increasingly switch to electric cars, the government-subsidized bioethanol industry will face challenges as demand for ethanol as a fuel additive for combustion-engine vehicles erodes. But bioethanol may be repurposed as a renewable chemical feedstock to make a variety of platform chemicals with significantly more value compared to its value as a fuel. Agricultural leftovers such as corn stover and corn cobs can

continued on page 7

JULIA POLLACK: IN FRAGMENTS NO LONGER



JULIA POLLACK, *In Fragments No Longer: Ananya Sen and Julia Pollack,* 2023, inkjet print, 24 x 36 inches.

Julia Pollack, a curator and creator at the Carl R. Woese Institute for Genomic Biology (IGB) at the University of Illinois Urbana-Champaign, makes art based on her conversations and collaborations with scientists. When Pollack engages in dialogues with researchers at IGB, she immerses herself in their work, and then uses that information along with related imagery to build concepts for her artistic interpretations.

Her series "In Fragments No Longer" is inspired by the microbial world that envelops all living things. When we brush past strangers, share a hug with a friend, or kiss our loved ones, we share millions of microbes. The series is comprised of digital prints depicting Lysogeny broth (LB) plates that hold the personal microbes of Pollack and four collaborators: science writer and microbiologist Ananya Sen, IGB outreach manager Claudia Lutz, IGB director of core microscopy facilities Glenn Fried, and University of Illinois Urbana-Champaign professor of microbiology Cari Vanderpool. In each pair of prints, Pollack and a collaborator imprinted their microbial communities on LB plates, which contain a nutritious jelly that helps bacteria grow—making visible the microbial world that binds us all together with a multitude of invisible connections.

Pollack's work highlights the power and aesthetics of science imagery while revealing the hidden labor of research and knowledge production. "In Fragments No Longer" is part of the IGB's Art of Science program, currently in its fourteenth year. It celebrates common ground between science and art and is representative of IGB's mission to bring science to the community.

"In Fragments No Longer," a series in the exhibition *Julia Pollack: Collaborative Ecologies*, is on exhibit through June 7, 2024, at the National Academy of Sciences, 2101 Constitution Ave, NW, Washington, DC.

JULIA POLLACK, *In Fragments No Longer: Ananya Sen and Julia Pollack 2,* 2023, inkjet print, 24 x 36 inches.

also be harnessed as alternate feedstocks to make renewable chemicals and materials, further boosting ethanol biorefinery economics. Such biorefineries can spur thriving agro-based economies.

Another major development in decarbonizing the energy sector involves the government's recent investments in hydrogen hubs. The hydrogen produced from carbon-free energy sources is expected to decarbonize fertilizer production, now a significant source of carbon emissions. The hydrogen can also find other outlets, including its reaction with carbon dioxide captured and sequestered in removal operations to produce green methanol as either a fuel or a platform chemical. Carbon-free oxygen, a byproduct of electrolytic hydrogen production in these hubs, can be a valuable reagent for processing biogenic feedstocks to make renewable chemicals.

Another untapped and copious source of chemical feedstock is end-of-use plastics. For example, technologies are being developed to convert used polyolefin plastics into a hydrocarbon crude that can be processed as a chemical feedstock in conventional refineries. In other words, the capital assets in existing petroleum refineries may be repurposed to process recycled carbon sources into chemical feedstocks, thereby converting them into circular refineries. There could well be other paradigm-shifting possibilities for a sustainable chemical industry that could emerge from a carefully coordinated road-mapping strategy that involves essential stakeholders across the chemical value chain.

Bala Subramaniam
Dan F. Servey Distinguished Professor, Department of Chemical and Petroleum Engineering
Director, Center for Environmentally Beneficial Catalysis
University of Kansas

HARVESTING INSIGHTS FROM CROP DATA

In "When Farmland Becomes the Front Line, Satellite Data and Analysis Can Fight Hunger" (*Issues*, Winter 2024), Inbal Becker-Reshef and Mary Mitkish outline how a standing facility using the latest satellite and machine learning technology could help to monitor the impacts of unexpected events on food supply around the world. They do an excellent job describing the current dearth of public real-time information and, through the example of Ukraine, demonstrating the potential power of such a monitoring system. I want to highlight three points the authors did not emphasize.

First, a standing facility of the type they describe would be incredibly low-cost relative to the benefit. A robust facility could likely be established for $10–20 million per year. This assumes that it would be based on a combination of public satellite data and commercial

data accessed through larger government contracts that are now common. Given the potential national security benefits of having accurate information on production shortfalls around the world, the cost of the facility is extremely small, well below 0.1% of the national security spending of most developed countries.

Second, the benefits of the facility will likely grow quickly, because the number of unexpected events each year is very likely to increase. One well-understood reason is that climate changes are making severe events such as droughts, heat waves, and flooding more common. Less appreciated is the continued drag that climate trends are having on global productivity, which puts upward pressure on prices of food staples. The impact of geopolitical events such as the Ukraine invasion then occur on top of an already stressed food system, magnifying the impact of the event on global food markets and social stability. The ability to quickly assess and respond to shocks around the world should be viewed as an essential part of climate adaptation, even if every individual shock is not traceable to climate change. Again, even the facility's upper-end price tag is small relative to the overall adaptation needs, which are estimated at over $200 billion for developing countries alone.

Third, a common refrain is that the private sector (e.g., food companies, commodity traders) and national security outfits are already monitoring the global food supply in real time. My experience is that they are not doing it with the sophistication and scope that a public facility would have. But even if they could, having estimates in the public domain is critical to achieving the public benefit. This is why the US Department of Agriculture regularly releases both its domestic and foreign production assessments.

The era of Earth observations arguably began roughly 50 years ago with the launching of the original Landsat satellite in 1972. That same year, the United States was caught by surprise by a large shortfall in Russian wheat production, a surprise that reoccurred five years later. By the end of the decade the quest to monitor food supply was a key motivation for further investment in Earth observations. We are now awash in satellite observations of Earth's surface, yet we have still not realized the vision of real-time, public insight on food supply around the world. The facility that Becker-Reshef and Mitkish propose would help to finally realize that vision, and it has never been more needed than now.

David Lobell
Professor, Department of Earth System Science
Director, Center on Food Security and the Environment
Stanford University
Member, National Academy of Sciences

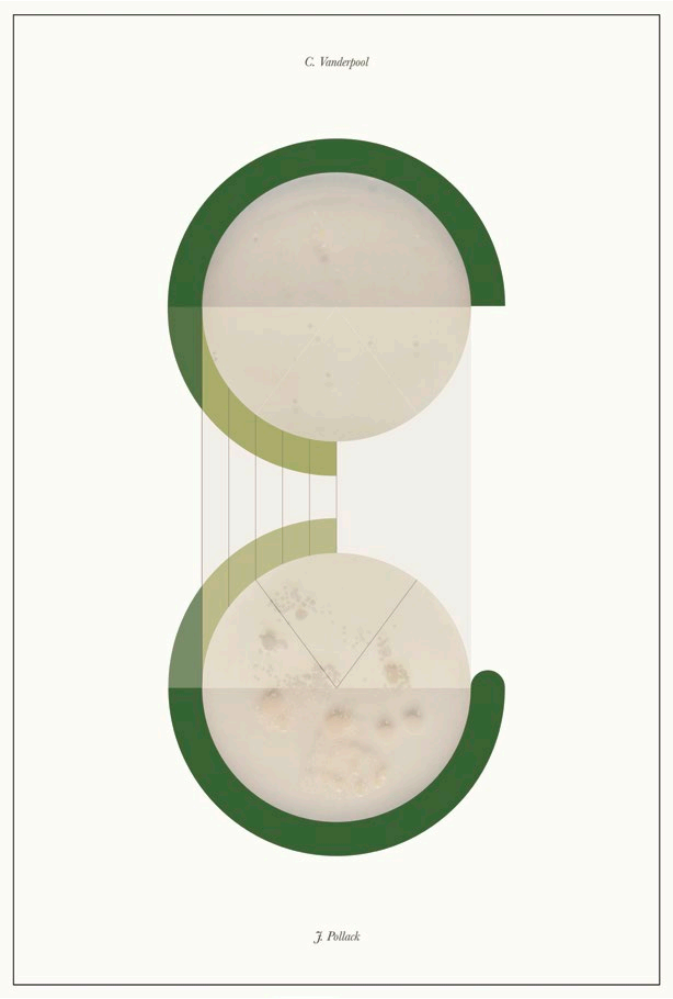
Given the current global food situation, the importance of the work that Inbal Becker-Reshef and Mary Mitkish describe cannot be emphasized enough. In 2024, some 309 million people are estimated to be acutely food insecure in the 72 countries with World Food Program operations and where data are available. Though lower than the 2023 estimate of 333 million, this marks a massive increase from pre-pandemic levels. The number of acutely hungry people in the world has more than doubled in the last five years.

Conflict is one of the key drivers of food insecurity. State-based armed conflicts have increased sharply over the past decade, from 33 conflicts in 2012 to 55 conflicts in 2022. Seven out of 10 people who are acutely food insecure currently live in fragile or conflict-affected settings. Food production in these settings is usually disrupted, making it difficult to understand how much food they are likely to produce. While Becker-Reshef and Mitkish focus on "crop production data aggregated from local to global levels," having local-level data is critical for any groups trying to provide humanitarian aid. It is this close link between conflict and food insecurity that makes satellite-based techniques for estimating the extent of croplands and their production so vital.

This underpins the important potential of the facility the authors propose for monitoring the impacts of unexpected events on food supply around the world. Data collected by the facility could lead to a faster and more comprehensive assessment of crop production shortfalls in complex emergencies. Importantly, the facility should take a consensual, collaborative approach involving a variety of stakeholder institutions, such as the World Food Program, that not only have direct operational interest in the facility's results, but also frequently possess critical ancillary datasets that can help analysts better understand the situation.

While satellite data is an indispensable component of modern agricultural assessments, estimation of cropland area (particularly by type) still faces considerable challenges, especially regarding smallholder farming systems that underpin the livelihoods of the most vulnerable rural populations. The preponderance of small fields with poorly defined boundaries, wide use of mixed cropping with local varieties, and shifting agricultural patterns make analyzing food production in these areas notoriously difficult. Research into approaches that can overcome these limitations will take on ever greater importance in helping the proposed facility's output have the widest possible application.

In order to maximize the impact of the proposed facility and turn the evidence from rapid satellite-based assessments into actionable



JULIA POLLACK, *In Fragments No Longer: Cari Vanderpool and Julia Pollack,* 2023, inkjet print, 24 x 36 inches.

JULIA POLLACK, *In Fragments No Longer: Cari Vanderpool and Julia Pollack 2,* 2023, inkjet print, 24 x 36 inches.

recommendations for humanitarians, close integration of its results with other streams of evidence and analysis is vital. Crop production alone does not determine whether people go hungry. Other important factors that can influence local food availability include a country's stocks of basic foodstuffs or the availability of foreign exchange reserves to allow importation of food from international markets. And even when food is available, lack of access to food, for either economic or physical reasons, or inability to properly utilize it can push people into food insecurity. By combining evidence on a country's capacity to handle production shortfalls with data on various other factors that influence food security, rapid assessment of crop production will be able to fully unfold its power.

Friederike Greb
Head, Market and Economic Analysis Unit
Rogerio Bonifacio
Head, Climate and Earth Observation Unit
World Food Program
Rome, Italy

AN INNOVATION ECONOMY IN EVERY BACKYARD

Grace J. Wang's timely essay, "Revisiting the Connection Between Innovation, Education, and Regional Economic Growth" (*Issues*, Winter 2024), warrants further attention given the foundational impact of a vibrant innovation ecosystem—ideas, technologies, and human capital—on the nation's $29 trillion economy. She aptly notes that regional innovation growth requires "a deliberate blend of ideas, talent, placemaking, partnerships, and investment."

To that end, I would like to amplify Wang's message by drawing attention to the efforts of three groups: the ongoing work of the Brookings Institution, the current focus of the US Council on Competitiveness, and the catalytic role of the National Academies Government-University-Industry Research Roundtable (GUIRR) in advancing the scientific and innovation enterprise.

First, Brookings has placed extensive emphasis on regional innovation, focusing on topics such as America's advanced industries, clusters and competitiveness, urban research universities, and regional universities and local economies. Recently, Mark Muro at Brookings collaborated with Robert Atkinson at the Information Technology and Innovation Foundation to produce *The Case for Growth Centers: How to Spread Tech Innovation Across America*. The report identified 35 place-based metropolitan locations that are utilizing the right ingredients—population; growing employment; university spending on R&D in science, technology, engineering, and mathematics per capita; patents; STEM doctoral degree production; and innovation sector job share—to realize innovation growth centers driven by targeted, peer-reviewed federal R&D investments.

The US Council on Competitiveness has also focused on place-based innovation. In 2019, the council launched the National Commission on Innovation and Competitiveness Frontiers, which involves a call to action described in the report *Competing in the Next Economy: The New Age of Innovation*. The council also formed four working groups, including one called The Future of Place-Based Innovation: Broadening and Deepening the Innovation Ecosystem. From these and other efforts, the council has proposed new recommendations that call for "establishing regional and national strategies to coordinate and support specialized regional innovation hubs, investing in expansion and retention of the local talent base, promoting inclusive growth and innovation in regional hubs, and strengthening local innovation ecosystems by enhancing digital infrastructure and local financing."

Finally, I want to emphasize the important role GUIRR plays in advancing innovation and the national science and technology agenda. Through the roundtable, leaders from federal science agencies, universities, and industry proactively collaborate to frame issues and conduct activities that advance the national enterprise. GUIRR workshops and reports have also historically included elements to advance the innovation enterprise, including regional innovation.

To end with a personal anecdote, I've witnessed the success that results from such a nexus, especially from one that was recently highlighted by Brookings: the automotive advanced manufacturing industry in eastern Tennessee. In my former position as chief research administrator at the University of Tennessee, I was deeply involved in that regional innovation ecosystem, along with other participants at Oak Ridge National Laboratory and in the automotive industry, allowing me to experience firsthand just how impactful these ingredients can be when combined and maximized.

More so, as GUIRR celebrates 40 years of impact this year, I know it will continue to serve as a strong proponent of the nation's R&D and innovation enterprise while continually refining and advancing the deep and critical collaboration between government, universities, and industry as laid out in Wang's article and amplified by Brookings and the US Council on Competitiveness.

Taylor Eighmy
President, The University of Texas at San Antonio
Council Member, National Academies Government-University-Industry Research Roundtable
National Commissioner, US Council on Competitiveness

As Grace J. Wang notes in her article, history has shown the transformative power of innovation clusters—the physical concentration of local resources, people brimming with creative ideas, and support from universities, the federal government, industry, investors, and state and local organizations.

In January 2024, the National Science Foundation (NSF) made a groundbreaking announcement: the first Regional Innovation Engines awards, constituting the broadest and most significant investment in place-based science and technology research and development since the Morrill Land-Grant Acts over 160 years ago. Authorized in the bipartisan CHIPS and Science Act of 2022, the program's initial two-year, $150 million investment will support 10 NSF Engines spanning 18 states, bringing together multisector coalitions to put these regions on the map as global leaders in topics of national, societal, and geostrategic importance. Subject to future appropriations and progress made, the teams will be eligible for $1.6 billion from NSF over the next decade.

NSF Engines have already unlocked another $350 million in matching commitments from state and local governments, other federal agencies, philanthropy, and private industry, enabling them to catalyze breakthrough technologies in areas as diverse as semiconductors, biotechnology, and advanced manufacturing while stimulating regional job growth and economic development. Places such as El Paso, Texas, and Greensboro, North Carolina, will see lasting impacts as they are transformed into inclusive, thriving hubs of innovation capable of evolving and sustaining themselves for decades to come.

The NSF Engines program is led by NSF's Directorate for Technology, Innovation, and Partnerships (TIP), which builds upon decades of NSF investments in foundational research to grow innovation and translation

capacity. TIP recently invested another $20 million in 50 institutions of higher education—including historically Black colleges and universities, minority-serving institutions, and community colleges—to help them build new partnerships, secure future external funding, and tap into their regional innovation ecosystems. Similarly, NSF invested $100 million in 18 universities to expand their research translation capacity, build upon academic research with the potential for technology transfer and societal and economic impacts, and bolster technology transfer expertise to support entrepreneurial faculty and students.

NSF also works to meet people where they are. The Experiential Learning for Emerging and Novel Technologies (ExLENT) program opens access to quality education and hands-on experiences for people at all career stages nationwide, leading to a new generation of scientists, engineers, technicians, practitioners, entrepreneurs, and educators ready to pursue technological innovation in their own communities. NSF's initial $20 million investment in 27 ExLENT teams is allowing individuals from diverse backgrounds and experiences to gain on-the-job training in technology fields critical to the nation's long-term competitiveness, paving the way for good-quality, well-paying jobs.

NSF director Sethuraman Panchanathan has stated that we must create opportunities for everyone and harness innovation anywhere. These federal actions collectively acknowledge that American ingenuity starts locally and is stronger when there are more pathways for workers, startups, and aspiring entrepreneurs to participate in and shape the innovation economy in their own backyard.

Erwin Gianchandani
Assistant Director for Technology, Innovation and Partnerships
National Science Foundation

MISSING LINKS FOR AN ADVANCED WORKFORCE

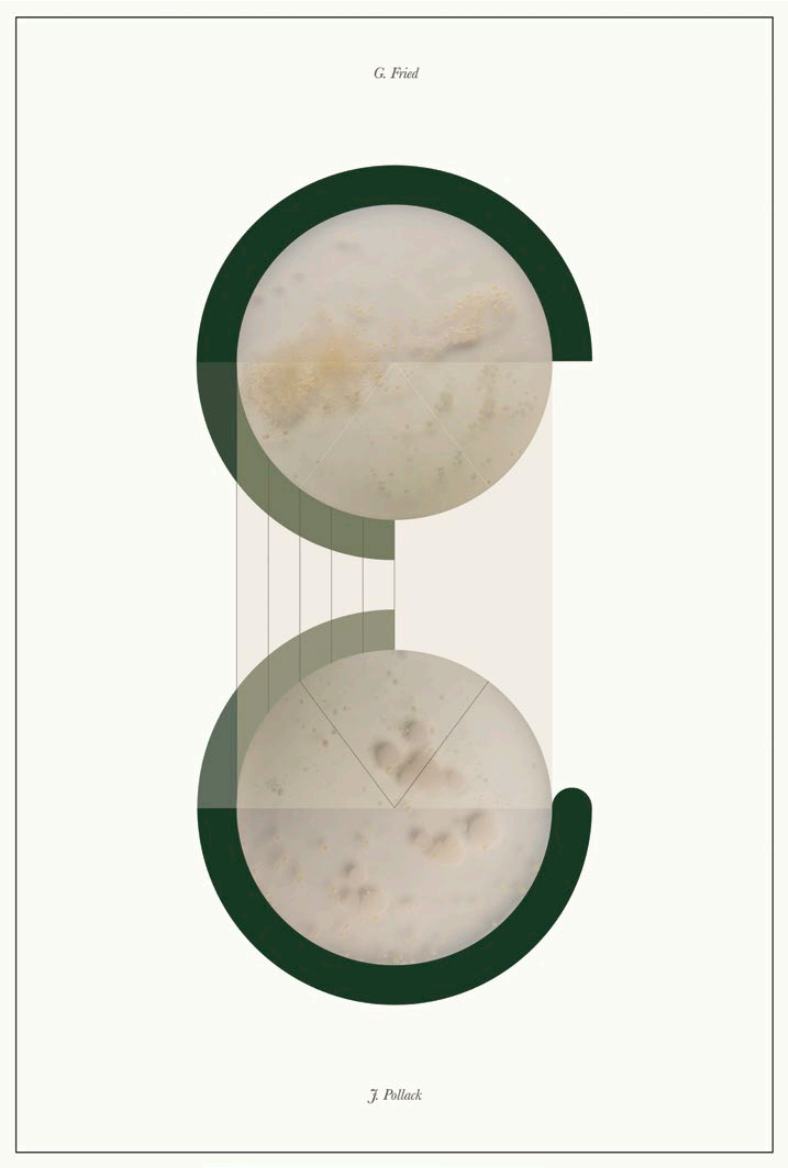
Recent investments in the US advanced manufacturing industry have generated a national workforce demand. However, meeting this demand for workers—particularly technicians—is inhibited by a skills gap. In the sector of microelectronics manufacturing, it is critical that we not only pursue effective technician education but also minimize barriers that hinder quality of education and program completion. For example, there are limited accessible avenues for students to gain hands-on industry experiences. Educational programs also face difficulties coordinating curriculum with local workforce needs. In "The Technologist" (*Issues*, Winter 2024), John Liu and William Bonvillian suggest an educational pathway targeting these challenges. Their proposals align with our efforts at the Micro Nano Technology Education Center (MNT-EC) to effectively train microelectronic industry technicians.

As the authors highlight, we must strengthen the connective tissue across the workforce education system. MNT-EC was founded with the understanding that there is strength in community bonds. We facilitate partnerships between students, educators, and industry groups to offer support, mentoring, and connections to grow the technician workforce. As part of our community of practice, we partner with over 40 community colleges in a coordinated national approach to advance microelectronic technician education. Our programs include an internship connector, which directs students toward hands-on laboratory education; a mentorship program supporting grant-seeking educators; and an undergraduate research program that backs students in two-year technical education programs.

These programs highlight community colleges' critical partnership role within the advanced manufacturing ecosystem. As Liu and Bonvillian note, community colleges have unique attributes: connections to their local region, diverse student bodies, and workforce orientations. Ivy Tech Community College, one of MNT-EC's partners, is featured in the article as an institution utilizing its strengths to educate new technologists. Ivy Tech, as well as other MNT-EC partners, understands that modern manufacturing technicians must develop innovative systems thinking alongside strong technical skills. To implement these goals, Ivy Tech participates in a partnership initiative funded by Silicon Crossroads Microelectronics Commons Hub. Ivy Tech works with Purdue University and Synopsis to develop a pathway that provides community college technician graduates with a one-year program at Purdue, followed by employment at Synopsis. This program embodies the "technologist" education, bridging technical education content taught at community colleges with engineering content at Purdue.

As we collectively develop this educational pathway for producing technologists, I offer two critical questions for consideration. First, how can we recruit and retain the dedicated technicians who will evolve into technologists? MNT-EC has undertaken strategic outreach to boost awareness of the advanced manufacturing industry. However, recruitment and retention remain a national challenge. Second, how can we ensure adequate and sustained funding to support community colleges in this partnership? Investing in the nation's manufacturing workforce by building effective educational programs that support future technologists capable of meeting industry needs will take a team and take funding.

Jared M. Ashcroft
Principal Investigator, Micro Nano Technology Education Center
Professor, Pasadena Community College
Justine Gluck
Reports & Communications, MNT-EC
Jennifer P. Hipp
Communications & Outreach, MNT-EC



JULIA POLLACK, *In Fragments No Longer: Glenn Fried and Julia Pollack,* 2023, inkjet print, 24 x 36 inches.

"GHOSTS" MAKING THE WORLD A BETTER PLACE

In "Bring on the Policy Entrepreneurs" (*Issues*, Winter 2024), Erica Goldman proposes that "every graduate student in the hard sciences, social sciences, health, and engineering should be able to learn some of the basic tools and tactics of policy entrepreneurship as a way of contributing their knowledge to a democratic society." I wholeheartedly support that vision.

When I produced my doctoral dissertation on policy entrepreneurs in the 1990s, only a handful of scholars, most notably the political scientist John Kingdon, mentioned these actors. I described them as "ghost like" in the policy system. Today, researchers from across the social sciences are studying policy entrepreneurs and many new contributions are being published each year. Consequently, we can now discern regularities in what works to increase the likelihood that would-be policy entrepreneurs will meet with success. I summarized these regularities in an article in the journal *Policy Design and Practice* titled "So You Want to be a Policy Entrepreneur?"

When weighing the prospects of investing time to build the skills of policy entrepreneurship, many professionals in scientific, technological, and health fields might worry about the opportunity costs involved. If they work on these skills, what will they be giving up? It's legitimate to worry about trade-offs. And, certainly, none of us want highly trained professionals migrating away from their core business to go bare knuckle in the capricious world of political influence.

But to a greater extent than has been acknowledged so far, building skills to influence policymaking can be consistent with becoming a more effective professional across a range of fields. The same skills it takes to be a policy entrepreneur are those that can make you a higher performer in your core work.

My studies of policy entrepreneurship show collaboration is a foundational skill for anyone wanting to have policy influence. Policy entrepreneurs do not have to become political advisers, lobbyists, or heads of think tanks. But they do need to be highly adept at participating in diverse teams. They need to find effective ways to connect and work with others who have different knowledge and skills and who come from different backgrounds than their own. Thinking along these lines, it doesn't take much reflection to see that core skills attributed to policy entrepreneurs are of enormous value for all ambitious professionals, no matter what they do or where they work.

We can all improve our productivity—and that of others—by improving our teamwork skills.

Likewise, it's well established that strategic networking is crucial for acquiring valuable inside information. Skills in framing problems, resolving conflicts, making effective arguments, and shaping narratives are essential for ambitious people in every professional setting. And these are precisely the skills that, over and over, we see are foundational to the success of policy entrepreneurs.

So, yes, let's bring on the policy entrepreneurs in the hard sciences, social sciences, health, and engineering. They'll have a shot at making the world a better place through policy change. Just as crucially, they'll also build the skills they need to become leaders in their chosen professional domains.

Michael Mintrom
Professor of Public Policy
Monash University
Melbourne, Victoria, Australia

JULIA POLLACK, *In Fragments No Longer: Glenn Fried and Julia Pollack 2,* 2023, inkjet print, 24 x 36 inches.

BIOLITERACY, BITTER GREENS, AND THE BIOECONOMY

The success of biotechnology innovations is predicated not only on how well the technology itself works, but also on how society perceives it, as Christopher Gillespie eloquently highlights in "What Do Bitter Greens Mean to the Public?" (*Issues*, Winter 2024), paying particular attention to the importance of ensuring that diverse perspectives inform regulatory decisions.

To this end, the author calls on the Biden administration to establish a bioeconomy initiative coordination office (BICO) to coordinate between regulatory agencies and facilitate the collection and interpretation of public acceptance data. This would be a much-needed improvement to the current regulatory system, which is fragmented and opaque for nonexperts. For maximum efficiency, care should be taken to avoid redundancy between BICO and other proposals for interagency coordination. For example, in its interim report, the National Security Commission on Emerging Biotechnology formulated two relevant Farm Bill proposals: the Biotechnology Oversight Coordination Act and the Agriculture Biotechnology Coordination Act.

In addition to making regulations more responsive to public values, as Gillespie urges, I believe that increasing the general public's bioliteracy is critical. This could involve improving K–12 science education and updating it to include contemporary topics such as gene editing, as well as amending civics curriculums to better explain the modern functions of regulatory agencies. Greater bioliteracy could help the public make more informed judgments about complex topics. Its value can be seen in what befell genetic use restriction technology (GURT), commonly referred to as terminator technology. GURTs offered solutions to challenges such as the efficient production of hybrid

seeds and the prevention of pollen contamination from genetically modified plants. However, activists early on seized on the intellectual property protection aspect of GURT to turn public opinion against it, resulting in a long-standing moratorium on its commercialization. More informed public discourse could have paved a path toward leveraging the technology's benefits while avoiding potential drawbacks.

Gillespie began his essay by examining how some communities and their cultural values were missing from conversations during the development of a gene-edited mustard green. The biotech company Pairwise modified the vegetable to be less bitter—but bitterness, the author notes, is a feature, not a flaw, of a food that is culturally significant to his family.

This example resonated keenly with me. I have attended a company presentation on this very same de-bittered mustard green. Like Gillespie, I do not oppose the innovation itself. Indeed, I'm excited by how rapidly gene-edited food products have made it into the market, and by the general lack of public freakout over them. But like Gillespie, I was bemused by this product, though for a different reason. According to the company representative, Pairwise's decision to focus on de-bittering mustard greens as its first product was informed by survey data indicating that American consumers wanted more diversity of choice in their leafy greens. My immediate thought was: just step inside an Asian grocery store, and you'll find a panoply of leafy greens, many of which are not bitter.

Genetic engineering has opened the doors to new plant varieties with a dazzling array of traits—but developing a single product still takes extensive time and money. Going forward, it would be heartening to see companies focus more on traits such as nutrition, shelf stability, and climate resilience than on reinventing things that nature (plus millennia of human agriculture) has already made.

Vivian Zhong
PhD Candidate, Stanford University
Policy Entrepreneurship Fellow,
Federation of American Scientists

THE BONDAGE OF DATA TYRANNY

In "The Limits of Data" (*Issues*, Winter 2024), C. Thi Nguyen identifies key unspoken assumptions that pervade modern life. He skillfully illustrates the problems associated with reducing all phenomenon to data and ignoring those realities that cannot be captured by data, especially when it comes to human beings. He identifies examples of how the focus on quantification frequently strips data of context and introduces bias in the name of objectivity. Here, I offer some thoughts that complement the essay's essential points while approaching them from slightly different perspectives.

While forcing people into groups to enable better data collection may lead to unwanted outcomes, some social categorization is necessary. Society needs legal thresholds to enable the equal treatment of citizens under the law. Sure, there are responsible 15-year-old geniuses and immature 45-year-old fools, but society has to offer some reasonable, but ultimately arbitrary, dividing line in allowing people to vote, or drive, or drink, or serve in the army. The need to codify legal standards for society remains an imperative, but, as Nguyen argues, those standards need not be strictly quantitative.

The universal drive for quantification and reducing phenomenon to data is driven by the architecture of the digital databases that process that data. Storing the data and analyzing them demands that all information inputs be in a format that must ultimately translate to 1s and 0s. This assumption itself, that all information is reducible to 1s and 0s, contains within it the conclusion that concepts, and by extension human thinking, can be reduced to binary terms. An attitude emerges that information that cannot be reduced to 1s and 0s is not worthy of attention. Holistic notions such as art, human emotion, and the soul must be either reduced to strict mathematical patterns or treated as a collection of examples from the internet or other databases.

A further motivation for the universal embrace of data and the fixation with quantification lies deep in the roots of Anglo-Saxon, and particularly American, culture. Early in the eighteenth century, the ideas of the British philosopher John Locke initiated a tradition that placed far greater value on practical facts that can be sensed (i.e., measured) rather than spiritual beliefs or cultural traditions that are the products of human reflection. By the end of the century, America's founding fathers, including Benjamin Franklin and Thomas Jefferson, followed Locke's tradition by emphasizing practicality and measurement. The advent of mass production and consumption—capitalism—only further sharpened the focus on the practical and obtainable. Entering the twentieth century, the great British physicist Lord Kelvin summed up his commitment to empiricism by declaring: "To measure is to know."

Society leverages the power of current data processing technologies but is subject to their limits. An enduring fixation with data stems from modern beliefs about what type of knowledge is worthwhile. Freeing society from the bias and bondage of data tyranny will require responding to these deeply embedded technological and behavioral factors that keep society limited by contemporary data structures.

Iddo Wernick
Senior Research Associate, Program for the Human Environment
The Rockefeller University

AI AND DROWNING IN A MECHANICAL CHORUS

In her thoughtful essay, "How Generative AI Endangers Cultural Narratives (*Issues*' Winter 2024), Jill Walker Rettberg writes about the potential loss of a beloved Norwegian children's story alongside several "misaligned" search engine results. The examples are striking. They point also to even more significant challenges implicit in the framing of the discussion.

The fact that search results in English overwhelm those in Norwegian, which has far fewer global speakers, reflects the economic dominance of the American technology sector. Millions of people, from Moldova to Mumbai, study English in the hope of furthering their careers. English, despite, and perhaps because of, its willingness to borrow from other cultures, including the Norse, has become the de facto lingua franca in many fields, including software engineering, medicine, and science. The bias toward English in the search therefore reflects the socioeconomic realities of the world.

Search engines of the future will undoubtedly do a better job in localizing the query results. And the improvement might come exactly from the kind of tightly curated machine learning datasets that Rettberg encourages us to consider. A large language model "trained" on local Norwegian texts, including folk tales and children's stories, will serve more relevant answers to a Norwegian-speaking audience. (In brief, large language models are trained, using massive textual datasets consisting of trillions of words, to recognize, translate, predict, or generate text or other content.) But—and here's the crucial point—no amount of engineering can make a model more fair or more equitable than the world it is meant to represent. To improve it, we must improve ourselves. Technology encodes global politics (and economics) as they are, not as they should be. And we humans tend to be a quarrelsome bunch, rarely converging on the same shared vision of a better future.

The author's conclusions suggest we consider a further, more troubling, aspect of generative AI. In addition to the growing dominance of the English language, we have yet to contend with the increasing mass of machine-generated text. If the early large language models were trained on human input, we are likely soon to reach the point where generated output far exceeds any original input. That means the large language models of the future will be trained primarily on machine-generated inputs. In technical terms, this results in overfitting, where the model follows too closely in its own footsteps, unable to respond to novel contexts. It is a difficult problem to solve, first because we can't really tell human and machine-generated texts apart, and second, because any novel human contribution is likely to be overwhelmed by the zombie horde of machine outputs. The voices of any future George R. R. Martins or Toni Morrisons may simply drown in a mechanical chorus.

Will human creativity survive the onslaught? I have no doubt. The game of chess, for example, became more vibrant, not less, with the early advent of artificial intelligence. The same, I suspect, will hold true in other domains, including the literary—where humans and technology have long conspired to bring us, at worst, some countless hours of formulaic entertainment, and, at their collaborative best, the incredible powers of near-instantaneous translation, grammar checking, and sentence completion—all scary and satisfying in any language.

Dennis Yi Tenen
Associate Professor of English and Comparative Literature
Columbia University

INNOVATIVE, OPPORTUNISTIC, FASTER

It is safe to say that research into the production, distribution, and use of energy in the United States has emphasized the technological over the social. Let's be clear: this focus has had its successes. We see physical improvements today in our homes and offices and in the growth of renewable sources in large part due to research and development investments begun in the 1970s. In some cases, these efforts were paired with inquiries into the economic, demographic, and behavioral contexts surrounding the technology in question. But this kind of comprehensive, multidisciplinary approach to our energy system has been rare—at least until recently.

As Evan Michelson and Isabella Gee demonstrate by example in "Lessons From a Decade of Philanthropy for Interdisciplinary Energy Research" (*Issues*, Winter 2024), the questions that social scientists, policymakers, the media, and consumers might have about the energy system extend far beyond resistors and wires. These questions are unwieldy. They are also challenging for researchers accustomed to working in their siloes. For example, many energy scholars are unfamiliar with our complex housing, property, utility, and household practices and their regulatory history. Likewise, social scientists have been sidelined not just due to their disciplinary silos and inability to engage with the engineers and scientists but because of the historical underinvestment in their methods.

Unfamiliarity has practical implications, such as not knowing which data are available, how to collect them, and whether indicators represented by these data are the most valid and aligned to the underlying concept in question. Put simply, humans—or more specifically, our understanding of humans and their energy use—are a missing link in energy research.

Enter philanthropy. Michelson and Gee rightfully point out the critical role of philanthropic funders based on their universal mission to improve social conditions. But they also note how philanthropy offers a unique vehicle compared with the public sector's statutory restrictiveness and private sector's profit motivation. Philanthropy can be innovative (funding risky propositions with potentially large societal benefit), opportunistic (targeting questions and researchers that have been excluded from methods and institutions), and, quite frankly, faster and nimbler, along with being more altruistic.

But philanthropy and, in turn, philanthropy's reach is limited. In the broad and still-murky field of energy and its socioeconomic soup, there are few philanthropic energy R&D funders, often with very limited budgets in competition with foundations' other pressing social program allocations. Federal funding's crowding out of foundation contributions might convince some funders to simply stay out of the business altogether.

For the few funders that stay in the race, there can be real rewards. The subject matter and researcher pools supported by the two largest federal energy research funders—the National Science Foundation and US Department of Energy—have expanded. In some cases, this has been made explicit through interdisciplinary research calls as well as stated research questions that require collaboration across silos. Anecdotally, every energy conference I have attended in the last five years has consciously discussed the integration of social sciences as a fundamental component of energy research. While each philanthropic entity rightfully evaluates its impact—and in the Alfred P. Sloan Foundation's case, quantitative indicators of those effects—we can see that these efforts have already had a massive qualitative effect.

Carlos E. Martín
Director of Remodeling Futures
Harvard Joint Center for Housing Studies

INVITING CIVIL SOCIETY INTO THE AI CONVERSATION

Karine Gentelet's proposals for fostering citizen contributions to the development of artificial intelligence, outlined in her essay, "Get Citizens' Input on AI Deployments" (*Issues*, Winter 2024), are relevant to discussions on the legal framework for AI, and deserve to be examined. For my part, I'd like to broaden the discussion on ways of encouraging the contribution of civil society groups to the development of AI.

The amplification or emergence of new social inequalities is one of the fears of those calling for more effective supervision of AI. How can we prevent AI from having a negative impact on inequalities, and why not encourage a positive one instead?

Involvement of civil society groups, notably from the community sector, that work with impoverished, discriminated, or vulnerable populations in consultations or deliberations about AI and its governance is currently very marginal, at least in Quebec. The same holds true for the involvement of individuals within these populations. But civil society groups, just like people, can be affected by AI—and as drivers of social innovation, they can also make positive contributions to the evolution of AI.

Even more concretely, the expertise of civil society groups can be called upon at various stages in the development of AI systems. This may occur, for example, in analyzing development targets and possible biases in algorithm training data, in testing technological applications against the realities of marginalized populations, and in identifying priorities to help ensure that AI systems benefit society. In short, civil expertise can help identify issues that those guiding AI development at present fail to raise because they are far too remote from the realities of marginalized populations.

Legal or ethical frameworks can certainly make more room for civil society expertise. But for them to play their full role, civil society groups must have the financial resources to develop their expertise and dedicate time to studying certain applications. Yet very often, these groups are asked to offer in-kind contributions before being allowed to participate in a research project!

And beyond financial challenges, some civil society groups remain out of the AI conversation. For example, the national charitable organization Imagine Canada found that 61% of respondents to a survey of charities indicated that they didn't understand the potential applications of AI in their sector. The respondents also highlighted the importance of and need for training in AI.

Legislation and regulation are often necessary to provide a framework for working in or advancing an industry or sector. However, other mechanisms—including recourse to the courts, research, journalistic investigations, and collective action by social movements or whistleblowers—can also contribute significantly to the evolution of practices and respect for the social consensus that emerges from deliberative exercises. Events of this kind concerning AI are still very fragmentary.

Nathalie Guay
Executive Director
Observatoire Québécois des Inégalités
Montréal, Québec, Canada