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Editor's Journal

How Good Is Science?

"A secure, productive, and innovative America that can outcompete China is something that all 100 senators want." So said Senator Mitch McConnell (R-KY), in support of the US Innovation and Competition Act. And if the number wasn't quite 100, an impressive 68 of 100 senators (all the Democrats, 19 Republicans, and the one Independent who isn't Bernie) agreed, voting on June 8 to pass this legislative potpourri, with provisions that range from the creation of quantum network infrastructure to the elimination of shark fin sales—but that's the price of bipartisanship.

At the heart of that omnibus legislation sits the Endless Frontier Act, which would spend tens of billions to counter the rising economic and technological might of China. Said Senator Chuck Schumer (D-NY), one of the act's original authors, "We now spend less than 1% of our GDP on basic scientific research. The Chinese Communist Party, as a percentage, spends more than twice that. We have put ourselves in the very precarious position of potentially falling behind the rest of the world in technologies and industries that will define the next century. If that happens, the days of America leading the world in scientific innovation and the days of America being the leading economic and military power in the world may be over."

It's as close to a political consensus as we're likely to get these days: outcompeting China in fields such as quantum computing, clean energy, robotics, synthetic biology, and artificial intelligence is necessary both to assure our economic well-being in the face of China's predatory, state-run economic policies, and to preserve our national security in a world where geopolitical strength is exercised in technological dominance not only in the conventional military sphere, but in the economic sphere as well. "There are only two real possibilities," says Senator Roger Wicker (R-MS). "Either the United States will remain the preeminent global superpower or we will be replaced by China."

Congress has long understood that more money for science is a good investment in the nation's future. That's why they doubled the budget for the National Institutes of Health (NIH) between 1998 and 2003; it's why they added $19 billion for science to the 2009 American Recovery and Reinvestment Act; it's why they fought off President Trump's repeated efforts to slash the science budget; and it's why the Endless Frontier Act would add $29 billion for the National Science Foundation (NSF) to advance a set of 10 "key technology focus areas."

Yet Congress apparently also gets that more money is not enough; we need to be doing science differently. The Endless Frontier Act, for example, would put that $29 billion not into existing science and engineering programs at NSF, but into a new Directorate for Technology and Innovation.

In fact, concern that our institutions of science are not doing enough high-risk, high-reward, cutting-edge, translational, transformative, pioneering, breakthrough science has motivated institutional change in the science agencies for more than a decade. Since 2009, NIH has had a High-Risk, High-Reward Research program that "catalyzes scientific discovery by supporting highly innovative research proposals that, due to their inherent risk, may struggle in the traditional peer review process." In 2012 NIH started its National Center for Advancing Translational Research "to catalyze the generation of innovative methods and technologies that will enhance the development, testing and implementation of diagnostics and therapeutics across a wide range of human diseases and conditions." NSF has undertaken similar improvements, for example, through its

Transformative Research funding activities, initiated in 2007 "to revolutionize existing fields, create new subfields, cause paradigm shifts, support discovery, and lead to radically new technologies." More recently, NSF launched its Big Ideas program, "to position our nation at the cutting edge—indeed to define that cutting edge—of global science and engineering leadership and to invest in basic research that advances the United States' prosperity, security, health, and well-being."

And what if all this transformative, paradigm-busting breakthrough innovation isn't enough to usher in a new era of global preeminence? Well, then, of course we will need more DARPAs.

The Defense Advanced Research Projects Agency model eschews the peer review system embraced by NIH and NSF and uses "smart managers" to identify the best research teams for linking advances in frontier knowledge and breakthrough innovation to solve the most difficult challenges that the military can imagine—problems said to be "DARPA-hard." An amendment added to the Endless Frontier Act during floor debate would double DARPA's $3.5 billion annual budget over the next five years.

In 2006, the DARPA approach was applied by the Office of the Director of National Intelligence to the creation of the Intelligence Advanced Research Projects Activity. IARPA would "take real risks, solve hard problems, and invest in high-risk/high-payoff research that has the potential to provide our nation with an overwhelming intelligence advantage."

Next came ARPA-Energy in 2009, created by Congress because the Department of Energy was widely understood to be a stovepiped, bureaucratized agency whose science and technology activities were unequal to the task of catalyzing clean energy innovation needed to address climate change and assure energy security. ARPA-E, placed outside of the DOE bureaucracy so that it wouldn't be captured by the agency's culture, focuses on "transformational energy projects that can be meaningfully advanced with a small amount of funding over a defined period of time. [Its] streamlined awards process enables [it] to act quickly and catalyze cutting-edge areas of energy research."

Now the DARPA model is being applied to health (an idea that's been around for decades) by the Biden administration, which is asking for $65 billion for ARPA-H, explaining that "this major investment in federal research and development would drive transformational innovation in health research and speed application and implementation of health breakthroughs."

Also on the docket is ARPA-C, now being planned by Biden's Climate Innovation Working Group, to foster "affordable, game-changing technologies that can help America achieve the president's goal of net zero economy-wide emissions by 2050 and can protect the American people from the impacts of droughts and flooding, bigger wildfires, and stronger hurricanes."

No one seems to want to say outright that the need to spend all these billions on new ways of doing science amounts to a repudiation of the old ways, which apparently cannot achieve what science advocates and politicians had always promised they would. Such a repudiation would mean that maybe we should actually be doing less of the low-risk, low-reward, incremental, pedestrian science that used to be good enough for America. But that would amount to an attack on much of the science infrastructure created over the past 70 years, and on the federal funding that continues to sustain it—a political nonstarter. Science advocacy goes only in one direction. As Senator Maria Cantwell (D-WA) explains, "Our research is very good with basic and very good with applied, but … we actually have to get better with the user implementation of our science and spur more innovation in a more rapid fashion." Better always means more.

It's nice to see the bipartisan lovefest around the Endless Frontier Act, but really, bipartisanship around China and science is easy. Everyone is afraid of China and science is beloved by Americans. The science lobby, always claiming to be weak and lacking in clout and needing to do a better job "communicating" to politicians and the public, is in fact extremely effective and influential, a loose coalition of hundreds of universities, academic associations, lobbying firms, professional societies, industry groups, philanthropic foundations, and advocacy organizations wielding the high-ground national myths of science's frontier and its heroic pioneers with rhetoric and tactics that are perfectly suited to our culture of hype and excess.

Funding science is good politics. Federal science money comes home to universities, companies, and laboratories. And science is full of promises, unaccompanied by accountability or regulations. It's a win-win-win-win. If it weren't, that extraordinary bipartisan majority of senators would not be voting for it so proudly—as they've been doing for decades.

So science is a political panacea. Is it a social one? If all of this breakthrough, frontier, high-risk, translational, transformative science actually comes to pass, what sort of nation will it leave us with? A society good at science isn't the same as a good society, one worthy of science's promise and gifts. After all, whenever we've been moved to invest hugely in science it's been because of threats from other countries that are good at science: Nazi Germany, the Soviet Union, and now China.

The United States remains the most scientifically and technologically capable nation in the world, but it's also #7 in literacy, #30 in life expectancy, #32 in homicide

rates, #37 in infant mortality, and #108 in wealth concentration. Among OECD countries, the United States ranks first in biomedical research expenditures and last in life expectancy, suicide rates, chronic disease burden, and obesity. In 2019 the United States was ranked #1 for pandemic preparedness, but had the 27th-worst mortality rate of 38 OECD nations. Is it time for ARPA-SocialContract?

Science and technology can be redemptive forces for the world, as the COVID-19 vaccines remind us. But in the past 30 years, on the wings of transformative science and technology, we traded, among other things, a strong manufacturing base that provided secure jobs and decent livelihoods for a gig economy that doesn't. We invested in innovation that created untold wealth, and let a tiny portion of society capture most of it. We traded human social interactions for social media, downtown shopping for Amazon, state and local newspapers for the blogosphere. One might recognize all of these as halting steps on the road to a better world in the future, but in the present, they seem to be offering a society fraught with high-tech Dickensian inequity, chronic disease, uncertainty about the future, and a level of political acrimony so great as to undermine our democratic institutions. We celebrate the creative destruction of technological innovation, but a good society would be one that figures out how to use its immense financial and technological powers not just to nourish the creation but to mitigate the destruction.

No one really knows the best pathway to that better world, but *Issues in Science and Technology* is devoted to informed, critical, and broadly accessible discussions of how science and innovation, and policy and politics, can come together to help create and shape it. Since the original version of the Endless Frontier Act was introduced in May 2020, we have published a variety of perspectives on the bill—its strengths, weaknesses, potential consequences—and suggestions for improvements and alternative approaches. We'll continue to do that as it works its way through Congress, as part of what we hope will be a vibrant national debate over what we should really be expecting from science and technology, and how best to fulfill those expectations.

To that end, we begin in this summer edition of *Issues* a year-long series of articles (made possible through a grant from The Kavli Foundation) called "The Next 75 Years of Science Policy." The scope of this series is nicely framed by its three opening contributions. What if, as Bruce Guile and Caroline Wagner suggest, being a global leader in a given field of science or technology like quantum computing "has little real meaning" in today's world of rapidly globalizing research and innovation? A companion piece written by Guile and Laura D. Tyson further argues that, in this globalized system, economic security will depend less on how much we spend on science than on how well we can forge a new generation of multilateral alliances to protect the United States and its allies against threats to energy, food, health, and defense supply chains. The third piece moves from geopolitics to lab politics: planetary scientist Lindy Elkins-Tanton wants to disrupt the intellectual and cultural hierarchies of academic science to get the focus off individual investigators and onto a team approach where everyone involved gets an equal stake in coming up with the scientific questions. In this way, "we can reimagine research that more effectively enables a new and more hopeful future."

Also in this issue:

- Can an emerging "internet of skills" increase opportunities for workers, or will it exacerbate existing inequities?
- What has COVID-19 taught us about managing the sometimes volatile relationship between politics and expertise?
- What does the continued use of implausible emissions scenarios in climate research tell us about scientific integrity?
- As sea levels rise, what can be learned from the 140-year history of managed retreat in America?
- And, is it time to ask what it would take to move toward a society that measures progress in terms of quality of life, not quantity of economic growth?
- Plus: moral hazards, mouse research, Delhi's smog, COVID artifacts, books, poetry … and an interview with bioethicist R. Alta Charo.

If you enjoy these offerings, and if you like the changes in *Issues* over the past year or so—the interviews, the expanded art sections and beautiful new layout, the greater variety of subjects, of writing styles, of authors and perspectives, and a greatly enhanced capacity to respond to unfolding events through our website, social media, and webcasts—then you should thank my coeditors Lisa Margonelli, William Kearney, and Jason Lloyd, and everyone else on the masthead too. These improvements are a direct reflection of their collective imagination (and, of course, frenzied work schedules). As has been my intent since becoming editor-in-chief two years ago, this is my final issue of *Issues* (we've never solved that semantic awkwardness); starting immediately, Lisa brings her wonderful creativity, knowledge, energy, integrity, and editorial vision to that role. The magazine (print and online) will keep getting better, more challenging, surprising, engaging, and valuable, so stay tuned. For making that possible, my special thanks go to Marcia McNutt and Michael Crow.