BARRY BOZEMAN

PUBLIC **VALUE** SCIENCE

In an increasingly unequal society,
America's science policies are a regressive force.
They need to be refocused on creating benefits for all people.

Why should the United States government support science? That question was apparently settled 75 years ago by Vannevar Bush in *Science, the Endless Frontier*: "Since health, well-being, and security are proper concerns of Government, scientific progress is, and must be, of vital interest to Government. Without scientific progress the national health would deteriorate; without scientific progress we could not hope for improvement in our standard of living or for an increased number of jobs for our citizens; and without scientific progress we could not have maintained our liberties against tyranny."

Having dispensed with the question of why, all that remained was for policy-makers to decide, how much? Even at the dawn of modern science policy, costs and funding needs were at the center of deliberations. Though rarely discussed anymore, *Endless Frontier* did give specific attention to the question of how much. The proposed amounts seem, by today's standards, modest: "It is estimated that an adequate program for Federal support of basic research in the colleges, universities, and research institutes and for financing important applied research in the public interest, will cost about 10 million dollars at the outset and may rise to about 50 million dollars annually when fully underway at the end of perhaps 5 years."

In today's dollars, $50 million translates to about $535 million, or less than 2% of what the federal government actually spent for basic research in 2018. One way to look at the legacy of *Endless Frontier* is that by answering the why question so convincingly, it logically followed that the how much question could always be answered simply by "more."

In practice, however, the why question continues to seem so self-evident because it fails to consider a third question, who? As in, who benefits from this massive federal investment in research, and who does not? The question of who was also seemingly answered by *Endless Frontier,* which not only offered full employment as a major goal for expanded research but also embraced "the sound democratic principle that there should be no favored classes or special privilege."

But I argue that this principle has now been soundly falsified. In an economic environment characterized by growth but also by extreme inequality, science and technology not only reinforce inequality but also, in some instances, help widen the gap. Science and technology can be a regressive factor in the economy. Thus, it is time to rethink the economic equation justifying government support for science not just in terms of why and how much, but also in terms of who.

What logic supports my claim that under conditions of conspicuous inequality, science and technology research is often a regressive force? Simple: except in the case of the most basic of basic research (such as exploration of other galaxies), effects are never randomly distributed. Both the direct and indirect effects of science and technology tend to differentially affect citizens according to their socioeconomic power and purchasing power.

First, when research accomplishes its goals of creating totally new technologies and sectors of the economy, the costs of such "creative destruction" are disproportionately borne by those who are already less able to thrive in a highly competitive and unequal society. Second, when research and technology lead to the proliferation of new firms or, especially, to rises in the value of large, established firms, the stock market rewards value, and the people holding stocks benefit. Those who do not own stocks (about 45% of Americans) benefit either indirectly or not at all. Third, research leads to new services and products, many of which themselves become important contributors to economic and social well-being. When innovative goods come to market they may be priced beyond the ability of lower-income families to enjoy the goods or the benefits that come with them. By skewing economic benefit and also consumption opportunity toward more affluent citizens, the effects of research and technology, in an economy characterized by extensive inequality, will be regressive.

But it doesn't have to be this way. Here I outline an alternative rationale for publicly funded science, what I call "public value science," and offer some steps the nation might take to redo its social contract for public support of science.

Economic inequality: a sketch

US income inequality is at its highest level since the Census Bureau began tracking it more than 50 years ago. The top 10% of citizens now have more than nine times as much income as the bottom 90%. A recent analysis by the economists Gabriel Zucman and Emmanuel Saez showed that the bottom 50% of the population has made gains in income since 1970. Using constant dollars, the family who in 1970 had $19,640 in income had $27,642 in 2018, an increase of about 29%. This amount of growth contrasts sharply with higher-income strata during the same period:

- The top 10% of the population saw their average income more than double.
- The top 1.0% enjoyed a threefold increase in income.
- The top 0.1% now has five times as much wealth.
- The wealthiest Americans, the one in ten thousand, saw their income rise from an average of over $3.5 million to more than $24 million, an increase of nearly 700%.

A favorite political economy morality tale told on the campaign trail, by Bernie Sanders especially, is that the three richest people in the United States now own as much wealth ($249 billion) as the bottom half of the population ($245 billion). But this problem is more than a political debating point. The Gini index has long been used as a measure of income dispersion and inequality. In 1980, the US Gini index was 34.6—higher than all measured countries in Europe (a higher number indicates more inequality), and higher than Canada (28.4) and the United Kingdom (26.7), but not as high nations in Central or South America or most nations in the developing world. For the most recent data, 2018, the US figure rose to 48.5. US inequality peers now include China, Mexico, and Rwanda. Tax cuts that the United States adopted in 2017, including the elimination of capital gains tax and a one-third cut in corporate tax rates, are likely to exacerbate these trends.

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Rising tides, sinking boats

Even if there is debate about the significance of US income inequality or about what, if anything, should be done about it, nearly everyone agrees that its causes include a great many factors, such as tax policy, demographic shifts, international trade relations, problems of obsolete industries, and inadequate job retraining programs. Rarely if ever mentioned in such lists are science policies. Why not?

Although there may be more than one answer to that question, an important reason is surely that distributional considerations are rendered irrelevant by the linear model of science and innovation that has dominated science policy discourse since it was articulated so powerfully in *Endless Frontier*. Investments in science and technology lead to innovation; innovation leads to advances in productivity, economic development, and wealth creation; and these improvements in economic conditions yield a better life and standard of living for all citizens. Case closed. Even if the rising tide of economic growth lifts some boats more than others, everyone should still find themselves better off.

We know from recent experience, however, that many boats do sink, even as tides rise. America has enjoyed prodigious economic growth and increases in wealth at the same time as much of the population suffers, either in relative or absolute terms. This fact seems indisputable. Yet the possibility that science policy might be implicated in such suffering—or might be tailored specifically to help alleviate it—has almost entirely evaded the attention of US policy-makers. Indeed, one must dig deep to find a public official's plea or policy proposal aimed squarely at public and socioeconomic benefits of science divorced from economic growth assumptions.

The late George Brown, for years the chair of the US House Committee on Science, Space, and Technology, is one notable exception. As Brown noted in 1992 in a commentary in the journal *Science*: "We must test the hypotheses that link economic and societal benefits directly to advances in research. All research is not the same. What kinds of research offer the greatest probability of improving the quality of life of humankind throughout the world?" But that question has been largely neglected in American science policy discussions ever since.

Yet some segments of the public seem to harbor the intuition that science may not be exempt from the blame for America's inequitable society. Which segments? A 2014 study, based on eight national polls conducted between 2002 and 2010, contrasted "scientific optimists" and "scientific pessimists." The former group had strong belief in the promise and beneficial effects of science, whereas the latter was less likely to acknowledge benefits and more concerned about negative impacts. The optimists, about 30% of the population, had the highest education level and income. The pessimists, about 20% of the population, were on average less educated, with 78% lacking a college degree, and were the poorest, with 40% earning less than $35,000 per year. The group also had a higher proportion of women and people of color. One possibility is that they were less informed, and indeed the pessimist group reported that they did not feel confident in their knowledge of science. Alternatively, these responses can be understood as valid reflections of personal experience, with those in lower strata concluding quite reasonably that science and technology had done little to improve their lives, their health, or their economic status.

Why would we even expect US science policies to be anything other than regressive? Economists have for years embraced the notion of "creative destruction," the idea that technological changes in a free market economy—made possible in part through public investments in research—will destroy some industries but give rise to new ones that will power economic growth. Less attention has been given to the creative destruction of human lives, those who are paying the costs in their loss of jobs, declining economic fortunes, and social displacement. Through the idea of creative destruction we celebrate the reality that many innovations lead to the displacement of workers with technology. To be sure, business owners often pay a price, as do shareholders who bet on the wrong company. But the numbers of workers who lose when businesses are creatively destroyed is far higher and the impacts often more grievous.

For decades, economists have debated the effects of technology-based creative destruction, and the relatively few economists who do focus on creative destruction's effects on unemployment and economic dislocation costs tend to conclude that the long-run effects are net positive. But as the economist John Maynard Keynes noted, in the long run we are all dead. In the short run, people experience loss and suffering. It is virtually impossible to provide a valid and robust estimate of the effects of technology-based creative destruction because estimates depend on so many variables, such as workforce age, the distribution of workers' skills, and the extensiveness of training programs to provide new skills as old ones become obsolete. Unfortunately, science and innovation policy discussions of creative destruction's impacts almost always center on its virtues with little attention to its vices and to the inequitable distribution of its impacts.

If the United States were a nation politically committed to providing true social safety nets, aggressive training and retraining programs, more level costs of education, and demonstrable social mobility, then the benefits of science, technology, and innovation would be much the same as they are. The costs, however, would be less dire and more evenly distributed.

Just as defense expenditures do not inexorably add up to a more secure nation, a healthy investment in medical research does not equate to a healthy society.

Divided by innovation

Science policy's potential for regressive outcomes goes beyond large-scale effects on employment and income distribution.

Two decades ago, many educators, scholars, and policymakers concerned themselves with the "digital divide," an issue that remains of some (lesser) concern but has given way to what may be a much more important divide: the "health care technology divide." Health care technologies and pharmaceutical innovations are occurring at a brisk pace. But there is also a great deal of evidence that one's income status, and particularly one's insurance coverage, greatly affects health outcomes. A landmark study published in the *Journal of the American Medical Association* provides evidence of the link between income and life expectancy in the United States over the period 2001 to 2014. With a sample of nearly 1.5 billion person years for the population aged 40 to 76 years, the study found that the gap between the richest and the poorest was 14.6 years longevity, and that life expectancy increased more than two additional years for those in the top 5% of the income distribution while remaining little changed (.032 for men, .004 for women) for the bottom 5%.

Although many factors affect the relationship between relative economic deprivation and mortality, including higher smoking levels and poor nutrition, it is also the case that massive investments in medical and health research are not doing much to affect the longevity of the poor. Medical care becomes ever more based on high-end technology, but its use and benefits relate to insurance, income, and quality of care. Nor is the situation likely to improve through yet more innovation. A recent article in *Forbes,* a free-market-oriented publication, suggested a future further dividing rich from poor. "With higher spending capacities, the haves could access better technology, like bionic rather than regular prostheses, giving them better capabilities," the article noted. "They could … have genetically designed super-babies. They could also avail themselves of deep brain stimulation or other neurological advances to improve their IQ or mental prowess. Those at higher risk of cancers could avail themselves of gene editing tech to prevent cancer occurring, and the list could go on. All this, while the have-nots might have to manage with present-day treatments which fit their budgets. Wouldn't that be a plausible real-world version of … dystopia?"

Even if we set aside such issues as corporate culpability for the sorrows of opioids differentially affecting the poor and middle class, or the tendency to deliver drug solutions to problems of those who are already well-off and with longer life-expectancies, it is easy to see that the rising tide of drugs and health technology actually sinks some family boats. Although the impacts of drug and health technology costs on families can be complex, one factor explains much about who wins and who loses: whether families have adequate insurance. According to the Kaiser Foundation, 27.9 million nonelderly individuals were uninsured in 2018, the working poor accounting for many of them. Another indicator of the relationship of health and medical costs to economic disadvantage is that nationwide in 2018 about 530,000 bankruptcy filings were related to the inability to pay for the costs of an illness.

Innovation "divides" are an intrinsic feature of a highly unequal society: safer and more energy efficient construction materials in homes that only well-off people can afford; innovations in electronic banking and investing that have little relevance to the relatively poor; security technologies that keep wealthy people securely apart from the hoi polloi; drones that help Amazon deliver packages to people who can afford a computer to do online shopping. The point is not that a good society requires that everyone have access to everything, but that in a highly unequal society the benefits of science and technology that help assure a good life are withheld from many.

To add injury to insult, the negative effects of innovations or technological spillovers often differentially affect poorer citizens. It is no accident that fracking in oil and gas production occurs almost exclusively in relatively poor regions, or that wealthy people have little threat from the runoff from poultry or hog farms, or that coal waste never finds its way to wealthy suburbs. Affluent communities do not seek to have nuclear waste dumped nearby; poor communities, seeking economic development, sometimes do.

Public value science policy

The linear model of innovation espoused in *Endless Frontier* requires public investment in science and technology because the private sector will underinvest in research when it feels it cannot fully capture the benefits from those investments. In short, the main justification for government funding of science is to remedy this failure in market capitalism. This justification, especially as applied to public support for basic research, has been embraced by political conservatives and liberals alike.

As I've argued, this approach to government funding of science—public science to support private-sector innovation—must now be recognized as a direct and indirect contributor to the expansion of economic inequality in the United States. For those interested in science's potential to reduce inequalities, we would need to have a different rationale for public funding of science. I call this rationale "public value science."

Current science policies attend little, if at all, to public values—the generally agreed upon rights and benefits to which all should be entitled. Rather, they assume that public values will be achieved through the rising tide of economic growth. We now know this assumption is false. What might policies to advance public value science look like? First, public value science is necessarily progressive rather than either neutral or regressive. Public investment in science should be redeemed in terms of public value, just as private investment should lead to private benefit to investors and paying customers.

One might argue that social policy, not science policy, is the appropriate tool for remedying the glitches occurring when science-based innovation contributes to highly unequal distribution of public benefits. From this perspective, scientific research and innovation are simply aspects of economic development. Here is a counterview. If "market failure" in science policy is signaled by firms failing to adequately invest in science and technology necessary for economic growth, "public value failure" in science policy is signaled by the government's inadequate investments in science and technology that can produce public value benefits that accrue to all citizens. Science policy should aim at reversing both.

Of course, much public investment in science and technology is justified for reasons other than market failure, and this includes national security and public health. But such investments may still be accompanied by public value failure. For example, the evidence that the federal government's massive investments in defense and national security R&D vastly improve the lives of US citizens, or that they have much social payoff of other sorts (via "dual use technologies"), is at best mixed. Weapons improvements do not automatically equate with increased security. The security benefits of immeasurably expensive high-tech weapons systems such as the Strategic Defense Initiative, the F-35 Joint Strike Fighter, the Comanche helicopter, the Airborne Laser project, and the Future Combat System have added up to very little, especially given the billions of R&D dollars spent.

As to public health, a Pew Research Center poll shows that the vast majority of Americans support increased government funding of biomedical research as a pathway to improved health. But just as defense expenditures do not inexorably add up to a more secure nation, a healthy investment in medical research does not equate to a healthy society. Were that the case, the United States would have the best public health outcomes in the world rather than ranking (in the 2019 Bloomberg Healthiest Country Index) 35th, behind, among others, Costa Rica, Cuba, and Greece, and indeed every country in Western Europe. The index includes indicators of causes of death, life expectancy, health risks, and malnutrition, but does not include availability of cutting-edge high technology medical equipment and drugs.

Investments in health and medical research clearly have resulted in identifiable, important improvements to public health and well-being. But to what extent is the aggregate of medical and public health research investment aimed at public value? And to what extent is public value achieved for all citizens, not just the well-off? Answering these questions may seem fraught with caveats, but the COVID-19 pandemic has brought them into relief. The pandemic can reasonably be viewed as a massive public value failure. Who has it failed? It has failed people risking their lives delivering groceries, those working in meat factories, low-wage workers employed in restaurants and bars, childcare workers, and poor parents seeking to provide an education for their stay-at-home children but without access to a computer or the internet. Mortality rates are greatest for African Americans and Hispanics, for residents of inner cities, and for Native Americans. In short, the usual victims.

Whatever the public good justification of investments in biomedical science, I think we can say that there are some important limitations to their public value payoff, and that science policy is implicated in the resulting public value failure. Familiar examples include the mismatch between public health objectives and research portfolios supported (e.g., public support for studying genetics and possible cancer treatments is more than 100 times the amount for studying environmental causes of cancer); the tendency to give limited attention to diseases of the poor (a public value more often pursued by private foundations, such as the Bill & Melinda Gates Foundation's commitment of $55 million for dengue fever research); the focus on technological solutions that work well for people who are rich or have excellent insurance, but not so well for the uninsured or underinsured (e.g., artificial retinas that can prevent blindness but at a cost of more than $100,000 per "bionic eye"). Is health and medical research public values science policy? In some cases, but it does not serve as a paragon.

Five-step program

It will not be easy for policy-makers and researchers to move away from the linear model of market-based science toward a more public value-focused science. But here are a few steps that warrant consideration, deliberation, and argument—and perhaps even clinical policy trials.

1. Make it hard to look away. Having for years taught science and engineering students who trickle into my science policy classes to meet some social sciences requirement, I know that many do not, at least initially, see the relevance to what they wish to do with their lives. However, I have also observed that most science and engineering students find it edifying to learn about the social and political forces that shape nearly every aspect of their careers. For some of them, it even becomes the basis for a lifelong commitment. We should expand the requirements in science and engineering education for classes on social science, social policy, and science and engineering ethics, especially as a part of doctoral education.

2. Evaluate social impacts results, not just promises. The federal government's reluctance to require any serious evaluation of the research it funds has long been a problem, albeit an understandable one. Most federal science managers and certainly most funding recipients are happy enough with standard output indicators, usually publication and citation counts. Serious, systematic evaluation of the scientific and technical accomplishments of projects seems impractical. Yet a scheme to evaluate social impact is not so impractical. At least since the 1960s many mission agencies have required evaluations of the impact and effectiveness of applied and social research they have funded. Indeed, the entire profession of evaluation research developed out of such requirements, and much of this work has proved quite robust and helpful in public policy decision-making. Many such projects require some percentage of project funding, typically 10%–15%, for evaluation. There are even some parallels in the science funding agencies. For example, the National Science Foundation requires money to be set aside for external evaluation in its ADVANCE program for improving gender equity in science, and in its major science and engineering center grants as well.

Is it too much to ask that a profession whose very raison d'etre consists, ultimately, of its claims about truth-telling and superior ways of knowing do a little more truth-telling about the social and public value implications of scientific research?

I am not suggesting that all grants require a social impact evaluation component. But if a project or program claims to contribute to broader social goals, then evaluation of those claims seems warranted. At the agency level, one approach might be to give federal R&D programs discretion to explicitly devote a percentage of their research portfolio to targeted public values, and to evaluate these initiatives on public values accomplishments, not the usual mix of bibliometrics, patents, and economic development criteria. At the level of individual projects and scientists, a principal investigator could, likewise, choose to be evaluated in part according to public values criteria. Such an approach would quickly make apparent to both lawmakers and the public which federal science programs were willing to be evaluated in terms of their contribution to public values.

3. Create a new institute for satisfying curiosity. Public value science is not a synonym for applied science. One can identify instances of basic research that have ultimately had enormous public benefit, and likewise instances of applied research that were ill-focused, unneeded, or (most often) duplicative. What demands attention is not the tired and often meaningless basic-applied distinction, but the clash between publicly funded research that at least conceivably serves public values, and research that serves other purposes. Indeed, I recommend that basic research motivated only by abstract scientific curiosity be insulated from public-value science precisely to avoid being caught up in that clash.

Of course, research aimed only at satisfying curiosity may also have a type of public value simply through the rewards of people knowing more about our world—and distant planets too. Perhaps what we need is something like a National Institute for Indulging Curiosity (but with a better name), focused on supporting research whose chief contribution is to advance knowledge for its own sake, with no expectation of near-term or even long-term benefit, other than contributing to culture. This is certainly not a new idea. Many years ago, the economist Harry Johnson suggested that basic research should be valued as an investment in "culture." Alvin Weinberg, a nuclear physicist and administrator of Oak Ridge National Laboratory during and after the Manhattan Project, suggested that basic research should be funded as an overhead cost at some percent of the total federal science budget. Either of these recommendations would have the virtue of insulating such science from unreasonable expectations of public value—and from the temptation by science advocates to promise such benefits. And such an institute would also create a reasonable expectation that the rest of government-funded science can be judged at least in part on how well it contributes to the advance of public values.

4. Burst the bubble. In the United States and in many countries, the vast majority of scientists and engineers, especially academic faculty, come from middle-class and upper-middle-class backgrounds. Although the considerable expansion of female academic scientists is notable and should be lauded, and it remains imperative to attract more underrepresented minorities to the sciences, the fact remains that only a minute percentage of academic science positions are occupied by persons whose family origins are poor or working class, or whose parents did not go to college. Surely life in this fortunate bubble shapes our work and our values. We cannot be sure that bringing increased numbers of poor, ethnically disadvantaged, and working class children into scientific careers would necessarily increase the interest and focus of scientists on the social impacts of their work. But it would, if experiences from other professions are any measure, at least have a positive impact of increased sensitivity among researchers to social issues and, especially, to inequality.

5. Revisit public participation. I've recommended that public science can evolve toward public values through a more diverse scientific workforce, and through a greater understanding among scientists about the political forces steering science. A complementary approach is to encourage greater public participation in science to help bring publicly funded science and public values closer together. Public participation in science does not require that scientists cede intellectual autonomy; nor does it depend on conservative lawmakers becoming advocates of redistributive politics. But considerable experimentation with public involvement in science over several decades shows what can be achieved, for example, through the efforts of patient-activists to influence priorities and direction of some areas of biomedical science, and through the collaboration between science and stakeholders in the management of natural resources such as fisheries and water supplies.

Yet such efforts remain marginal, and often unsuccessful. Jason Chilvers and Matthew Kearns, authors of the book *Remaking Participation: Science, Environment, and Emergent Publics* (2016), provide one explanation: "For too long the burden of participation in science and democracy has been placed on citizens to come forward and engage…. It is time for this to be turned around. The burden of participation should lie just as much with powerful science, state and market institutions."

When this burden is not shouldered by science policy-makers, well-intended initiatives may miss the mark. For example, one thinks of the "broader impacts" criterion now institutionalized as an element of the National Science Foundation's peer review evaluation. This requirement focuses some attention on social impact, but is assessed by peer reviewers who all too often have little or no competence to judge the relation between the science being proposed and the impacts being promised. Such initiatives are nonetheless worthwhile as small steps toward establishing public values-oriented science policy and public values outcomes.

The fog of more

Contemporary science sometimes does manage to achieve public values. But science overall also achieves an array of very different outcomes: small and barely noticeable additions to esoteric knowledge, private and commercial objectives, satisfaction of curiosities great and small, harmful and even disastrous outcomes—and, sometimes, nothing at all. This diverse mixture of outcomes often contributes to inequality, including many instances of celebrated scientific accomplishments that, for those with lesser income and resources, signify nothing.

The conception of science policy articulated in *Endless Frontier* gave little if any consideration to possible distributional aspects of science policies. So long as we spent more on science and did more science, the rising tide would lift us all. This "fog of more" has led most scientists to reflexively embrace the report's ideas. But is it too much to ask that a profession whose very raison d'etre consists, ultimately, of its claims about truth-telling and superior ways of knowing do a little more truth-telling about the social and public value implications of scientific research? The moral basis of truth-telling does not stop at the borders of one's research specialty. Here is a truth with which to begin: much of scientific research has little to do with public value or public benefit. Dressing up self-interest, or even intellectual curiosity, as public benefit is a dishonesty that plagues many scientists and scientific leaders. We should expect better of them, especially as inequality unleashes its effects on nearly every aspect of society.

Simple, understandable, self-interested stretching of truth is something we should not condone in those truth-tellers spending tens of billions of dollars of taxpayer money, including money paid by taxpayers stuck in low-wage or dead-end jobs with little hope of social mobility. Let us recall President Dwight Eisenhower's admonition that "in holding scientific research and discovery in respect, as we should, we must also be alert to the equal and opposite danger that public policy could itself become the captive of a scientific-technological elite." In a society in which the distance between elites and ordinary citizens seems to be ever widening, perhaps Eisenhower's words loom ever larger.

What scientists want

What would it take to get scientists to embrace public-values oriented science? Most scientists are driven by curiosity, intellectual goals, career aspirations, commercial goals, or some combination of these. Gathered as part of the Survey of Academic Researchers project, my own data from a representative survey of 1,714 respondents from all major fields of science and technology show that only a minority of researchers agree that benefitting the general public should be a top priority for research finding. Specifically, only 6.5% strongly agreed with the statement "In government decisions about research funding, the scientist's intellectual curiosity should be less important than the potential of the research to improve people's lives." A larger percentage (31%) agreed somewhat with the statement, but a clear majority (63%) felt that funding should be about curiosity, not social benefit.

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Researchers are not misanthropes. But they have spent many thousands of hours learning about arcane physical and natural phenomena, not about the human condition. More to the point, science researchers, even when socially committed, do not often have any particular skills that allow them to either identify social needs or target their work toward social solutions. Why should they? We can achieve public value science by just letting scientists do what they do. That's what *Endless Frontier* told us.

If there is any one public position that almost all scientists agree on, it is the need for more public investment in science. At the same time, one of the things most scientists do well is respond to incentives. Most humans do this well enough, but to succeed in their careers, researchers must become both practiced and adept. When I teach courses on science policy or sociology of science, I always introduce the "Phrenology Premise": If the National Institutes of Health were to suddenly devote a billion dollars to phrenology research, then we could reasonably expect an outpouring of proposals from "phrenology researchers," who would propose creative ways to show that what they have been doing all along is absolutely vital to achieving knowledge about the dimensions of people's heads. If my Phrenology Premise seems a bit too cynical, then perhaps we can consider the fact that researchers, like most people, tend to be opportunistic. And this is fine. The science policy challenge is to give scientists more public-value science opportunities to respond to. We know they are up to the challenge, should they be given incentives to accept the challenge.

Scientists and funding agencies are fond of "grand challenges." What if the scientific community were to take on the grand challenge of replacing *Science, the Endless Frontier* with a new vision of scientific research as a means not only of contributing to innovation and economic growth but also as part of the solution for addressing the growing and unsustainable degree of economic and social inequality that is tearing our society apart? Such a document could build on Representative George Brown's words from nearly 30 years ago, now proved prescient:

> Society needs to negotiate a new contract with the scientific community. This contract must be rooted in the pursuit of explicit, long-term social goals, such as zero population growth, reduced generation of waste, reduced consumption of non-renewable resources, less armed conflict, less dependence on material goods as a gauge of wealth or success and greater opportunity for self-realization for all human beings.… Scientists and politicians must abandon the self-serving rhetoric that drives today's science agenda and work together to ensure that tomorrow's scientific research better serves the needs of all humanity, not just a privileged few.

At least since Frederick Jackson Turner's work in 1893, historians have emphasized the importance of the frontier myth to understanding America and its evolution. Knowing its power as a symbol, Vannevar Bush appropriated this frontier myth to embellish his argument for government funding of science. Perhaps the next powerful appropriation of the frontier myth can focus not only on endless frontiers of scientific discovery but also on new and expanded concepts of the public responsibilities of science.

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Recommended reading

Barry Bozeman, *Public Values and Public Interest: Counterbalancing Economic Individualism* (Washington, DC: Georgetown University Press, 2007).

Barry Bozeman and Jan Youtie, "Socio-Economic Impacts and Public Value of Government-Funded Research: Lessons from Four US National Science Foundation Initiatives," *Research Policy* 46, no. 8 (2017): 1387–1398.

G. E. Brown, "Rational Science, Irrational Reality: A Congressional Perspective on Basic Research and Society," *Science* 258, no. 5080 (1992): 200–201.

"Is science only for the rich?" *Nature* 537, no. 7621 (2016): 466–470.

Mariana Mazzucato, *The Value of Everything: Making and Taking in the Global Economy* (New York, NY: Public Affairs, 2018).

Emmanuel Saez and Gabriel Zucman, *The Triumph of Injustice: How the Rich Dodge Taxes and How to Make Them Pay* (New York, NY: W. W. Norton & Company, 2019).

Alvin M. Weinberg, "Criteria for Scientific Choice II: The Two Cultures," *Minerva* 3, no. 1 (1964): 3–14.

James Wilsdon, Brian Wynne, and Jack Stilgoe, *The Public Value of Science, Or How to Ensure that Science Really Matters* (London, UK: Demos, 2005).