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Editor's Journal

Necessary but not Sufficient?

As any even casual student of American science and technology policy well knows, *Science, the Endless Frontier* is the 1945 policy document that articulates the dominant rationale for the US government's investment in academic scientific research. The influence of *STEF* on science policy discussions and actions cannot be overstated and continues to this day. (The director of the White House Office of Science and Technology Policy, Kelvin Droegemeier, regularly invokes it.) That a policy report with no legal significance and no authority beyond the power of its argument is the object of celebration on its seventy-fifth anniversary, with events planned at the National Academies and the American Association for the Advancement of Sciences (not to mention a year-long series of articles in this magazine, starting with this issue), is remarkable.

But it's also understandable, because *STEF* provides the reasoning that justifies on the order of \$25 billion a year in government spending for basic scientific research at America's universities. This reasoning anchors the belief system of many scientists, as well as members of the public, about the social value of science whose direction is determined by scientists, and which is conducted without consideration of practical application. From its opening paragraph, *STEF* links basic research directly to national well-being in three core domains—health, jobs, and military readiness: “Progress in the war against disease depends upon a flow of new scientific knowledge. New products, new industries, and more jobs require continuous additions to knowledge of the laws of nature, and the application of that knowledge to practical purposes. Similarly, our defense against aggression

demands new knowledge so that we can develop new and improved weapons. This essential, new knowledge can be obtained only through basic scientific research.” (For those unfamiliar with the report, excellent historical discussions can be found in Daniel Kevles's book *The Physicists*, and in *Endless Frontier*, G. Pascal Zachary's biography of *STEF*'s author, Vannevar Bush.)

The logic of *STEF*'s argument is of the “necessary but not sufficient” sort. *STEF* presents “basic research” as a prerequisite for national well-being, but not a guarantee: “Science, by itself, provides no panacea for individual, social, and economic ills. It can be effective in the national welfare only as a member of a team, whether the conditions be peace or war. But without scientific progress no amount of achievement in other directions can insure our health, prosperity, and security as a nation in the modern world.”

This sort of logic is powerful because it is inherently affirmative, and resists any contradiction. New knowledge, for example, is necessary for economic growth and new jobs. But if the nation's knowledge economy is afflicted by increased concentration of wealth and widespread swaths of economic disenfranchisement, the problem cannot be traced to science, but to the structure and incentives of corporations, the regressive tax code, the failing public education system, and so on. Science can get the credit, but not the blame. Yet necessary-but-not-sufficient logic has severe limits as a guide to policy-making. If it is unreasonable to blame science for causing the problem, it is equally unreasonable to argue that increased government funding for basic science will help solve the problem—even though such arguments are the bread-

and-butter of science advocacy. More uncomfortable still are questions of whether, given (say) a highly inequitable economic system, more of the type of knowledge that basic science provides to economic actors might make that system more inequitable.

Such uncomfortable questions have become inescapable. How can it be that with the tens of billions spent each year on basic biomedical science, health outcomes in the United States are so dismal compared with nations that spend so much less? How can it be that after all the Nobel prizes and fundamental advances in basic sciences the US economy seems mostly capable of generating poorly paid service-sector jobs that are gradually eviscerating a once vibrant middle class? How can it be that the billions spent on understanding climate change have led to so little progress on addressing the problem? If the answer is that science is necessary but not sufficient, then what's the argument for science in the absence of those other factors—the “members of the team,” as *STEF* puts it—that create sufficiency?

“Necessary but not sufficient” turns out to be a dodge. Necessary science isn't any science that gets done, it's science (however basic) that's suited to what the members of the team have on offer; it's science that's fit for task. None deny the amazing productivity of the science enterprise that *STEF* inspired; but visionary institutional leaders are now recognizing that productivity is not enough. The first article in our *STEF* seventy-fifth anniversary series is by two such leaders (who are also visionary enough to be the patrons of this magazine—not a coincidence!). Marcia McNutt, president of the National Academy of Sciences, and Michael Crow, president of Arizona State University, highlight what their institutions are doing to ensure real synergies between necessary and sufficient—for example, by developing at the National Academy closer and more persistent links with those who can benefit from its expertise and integrity; and by pursuing at ASU a vision of public purpose that matches innovativeness in science with a commitment to serving the broadest cross-section of society.

The other article in our *STEF* anniversary series digs into an unintended consequence of *STEF*'s influence on science. Exploring the power of scientific publishers, Mark Neff finds that whereas *STEF* provided a compelling rationale for scientific self-governance, scientists delegated a fair bit of that privilege to publishers—who now wield an invisible hand in science policy, helping to shape how science gets done and what counts as science worth doing. *STEF* made the case for “scientists working on subjects of their own choice, in the manner dictated

by their curiosity for exploration of the unknown.” But it turns out that choice and curiosity are steered by the dynamics of the publishing game, which in turn may narrow scientific options and limit social benefit.

Meanwhile, Richard Cooper and Nigel Paneth raise a difficult question about science priorities. What if scientists working on subjects of their own choice have moved the mainstream of biomedical science into areas that are scientifically productive but ultimately unconnected to the key scientific needs for best advancing the nation's (and world's) health? Is it possible, after all, that sometimes the mainstream of science moves knowledge away from the necessary?

For all its influence and prescience, *STEF* got one important thing wrong. “A nation which depends upon others for its new basic scientific knowledge,” the report declared, “will be slow in its industrial progress and weak in its competitive position in world trade, regardless of its mechanical skill.” Tell that to President Trump. If this notion were always true, then China's rise would be inexplicable, as it has pursued precisely the course that *STEF* warned against. Now, as Carolyn Bartholomew explains, China stands on the verge of eclipsing the United States in areas of innovation and development that depend on economy-wide access to 5G broadband wireless networks. Blocking access to key US technologies may be necessary to keep China—and its geopolitical ambitions—in check. But Richard Suttmeier shows why efforts to hobble China's technological aspirations may well have the long-term effect of strengthening its indigenous scientific capabilities.

If you haven't read *STEF*, I'd recommend that you do; Google and ye shall find. It's an easy read; eloquent, accessible, confident—an exemplary policy document, deserving of its notoriety. But it's also an artifact, and its continued influence is troubling. *STEF* does not speak to the diversity and complexity of science and technology policy today. Consider some of the questions raised in other essays in this edition of *Issues*. What are the geopolitical implications of the United States abandoning nuclear power? Does the nation need a new system of land-grant-like universities for a digital age? How should society think about the regulation of gene drives? And by the way, what do you think about our cover art? It was painted by a machine. So who should get the credit, the machine or the person who wrote the code?

“Necessary but not sufficient” has nothing to offer such questions. Let the seventy-fifth anniversary of *Science, the Endless Frontier* be the final celebration of a once-powerful idea whose time has now passed.