QUANTUM LEAP

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IN THE FINAL YEAR OF WORLD War II, U.S. President Franklin D. Roosevelt told the director of the organization that oversaw the Manhattan Project—as well critical advancements in the mass production of synthetic rubber and morphine among other new technologies—that lessons learned from the war should be "profitably employed in times of peace."

In July 1945, after Roosevelt's death, Vannevar Bush, director of the U.S. Office of Scientific Research and Development, replied with his report, *Science, the Endless Frontier,* laying out the prevailing philosophy of government-funded scientific research of the past 80 years.

"In this modern age, more than ever before, pure research is the pacemaker of technological progress," Bush wrote. So long as "scientists are free to pursue the truth wherever it may lead, there will be a flow of new scientific knowledge to those who can apply it to practical problems in government, in industry or elsewhere."

That philosophy—the "free play of free intellects, working on subjects of their own choice, in the manner dictated by their curiosity"—is now under threat from the Trump administration. In April, the administration proposed cutting nearly half of NASA's $7.3 billion science budget, including ending a joint U.S.-European mission to collect samples from Mars, the planetary science community's highest priority (page 20). The White House also wants to eliminate all of the National Oceanic and Atmospheric Administration's weather, climate and ocean research.

The administration argues that government programs, sometimes over budget and years behind schedule, are out of line with the needs and desires of everyday Americans, reflecting the preferences of Beltway bureaucrats and tenured scientists—some of whom the president views as supporting his political opponents.

The scientific community is crying disaster. "If this happens, this will be nothing short of an extinction-level event for NASA's science and exploration," Casey Dreier, chief of space policy at The Planetary Society, a nonprofit space advocacy organization, said in April.

The Trump administration tends to hack at government programs, cutting not just fat but muscle, bone and brain, too. Laid-off scientists will feel real pain. Worthy scientific endeavors will become casualties of sloppy vengeance politics—the true cost of which may not be known for decades.

Chaos Theory

A haphazard debate about national research priorities is underway

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But what will happen to U.S. scientific prowess is not so certain. Progress is not linear, and it does not always flow from a government fountainhead. Coming out of World War II, there was a basic-applied-commercial research model, now referred to as the linear model, says David Mindell, professor of aerospace engineering and the history of technology at the Massachusetts Institute of Technology (MIT). "Further studies over many years have revealed it doesn't quite work that way," he says.

Instead, unexpected interactions and discoveries make scientific and technological progress more like an organic ecosystem that adapts to disruption in surprising ways. Consider the MIT Radiation Laboratory, responsible for pioneering radar and microwave research during World War II. "At the end of the war, they closed it down," Mindell says. "And what happened? All those people went off and founded the U.S. electronics industry, television and many other things."

What is more, basic science does not always come first. Take the telegraph. "It's not like there were a bunch of scientists in a lab studying electromagnetics, and then someone drew out of that the telegraph—it's actually exactly the opposite," Mindell says. "The telegraph presented practical problems that people didn't understand, and scientists began looking at those phenomena."

Controversy around the government-funding model laid out in *Science, the Endless Frontier* is nothing new, Mindell adds. The first proposal for the National Science Foundation—a product of the Bush report that later funded physics, atmospheric science and engineering research, helping to seed the U.S. space program—failed to be enacted into law.

"Congress said: 'That's not democratic to let the scientists choose how to spend public money. We need some political control, because we're spending the country's resources, and we need to know that they're contributing back to the larger good,'" Mindell says.

Science for scientists' sake is an insufficient justification in a democracy, although that point might be lost amid the haphazard political vendettas of the Trump administration.

"Do we have too [many] resources going to people in big government labs?" Mindell asks. "There is a national conversation to be had about: 'Where do we want the bulk of our brainpower to be applied in any given generation?'"

—With Irene Klotz in Cape Canaveral