Written Testimony of
Dr. Sudip Parikh, CEO
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Before the Joint Economic Committee
U.S. Congress April 27, 2022

Chairman Beyer, Ranking Member Lee, and Members of the Committee, thank you for the opportunity to testify today. I am Sudip Parikh, chief executive officer of the American Association for the Advancement of Science, the world's largest multidisciplinary scientific society, and the executive publisher of the *Science* family of journals. Our mission is to advance science, engineering, and innovation throughout the world for the benefit of all people or — put more simply — to advance science and serve society. I also serve as co-chair of the Science & Technology Action Committee, a group of leaders from industry, academia, non-profits, and foundations who came together to develop an urgent Action Plan to ensure a healthier, safer, and more economically sound future for all Americans.[i]

To begin, I'd like to ask a simple question: Do we want to be the nation that discovers, manufactures, and drives the economic, environmental, and health advances of the future? Or do we want to be the nation that lags in these future indicators while we attempt to buy them from friendly competitors or worse, geopolitical adversaries?

In the mid-1800s, Europe was the center of gravity for scientific discovery. In an apocryphal story, Michael Faraday, one of England's greatest scientists, was explaining a recent scientific discovery related to electricity to several members of Parliament. Future Prime Minister William Gladstone asked "but, after all, what use is it?" "Why, Sir," replied Faraday, "there is every probability that you will soon be able to tax it."

Faraday was absolutely right. The discovery of electricity marked an inflection point in history, opening entirely new fields of technology and improving the well-being of humanity, leading to everything from the light bulb to the internet.

Today, we stand at the cusp of similar inflection points in many scientific and engineering fields. Just two weeks ago, scientists from Fermilab reported that the W boson, a fundamental particle, weighs more than predicted by the standard model of physics.[ii] If this finding is repeated and verified, it means that there is a completely new frontier of physics for us to discover beyond what is currently known. It could be a discovery that parallels Benjamin Franklin's first understanding that sparks seen on earth were caused by the same phenomenon as lightning in the sky — and someday lead to entirely new parts of the economy that, as Faraday noted, might be taxed.

Even if this discovery turns out to be ephemeral, we are at similar inflection points in the fields of artificial intelligence, quantum computing, synthetic biology, gene editing, and more. We are at the cusp of revolutions in multiple sciences at once — with potential implications for our economy that could be as game-changing as electricity.

For the last 75 years — since Vannevar Bush's landmark *Endless Frontier* report, which set forth a framework for federal investment in research and development — we have followed a recipe that has grown our economy in ways never imagined at the beginning of the 1900s: investments in research at the Department of Defense, National Institutes of Health, National Science Foundation, and over 20 other federal agencies have led to transformative innovation, which in turn directly created jobs and boosted the economy in game-changing ways. This recipe has been so successful that other nations have copied it —increasingly with even more vigor than us. The time has come for us to redouble our efforts, build on our enviable strengths, and show the world again what American investment, intellect, ingenuity and risk-taking can accomplish for the benefit of all.

Today, I'd like to make three recommendations to ensure that we continue to lead the world in scientific discovery and its translation into meaningful increases in the safety, health, and wealth of all Americans:

- Provide robust investment in research and development (R&D) across a broad range of disciplines and geographies.
- Invest in our people to ensure that we are drawing upon the talents of all Americans in our scientific research and that all Americans benefit from our investments.
- Balance a portfolio of R&D investment that includes short-term incremental research, translational research, and high-risk, high-reward research that, if successful, could change lives and revolutionize the economy.

Provide robust investment in research and development across a broad range of disciplines and geographies.

We need to ensure robust support for R&D across basic scientific disciplines to enable a wide field of scientific advance. This is for several reasons. First, it's impossible to predict which scientific disciplines will produce the next game-changing innovation. Indeed, knowledge relevant for economic growth or societal challenges has emerged from every scientific and engineering discipline. Second, modern science is increasingly characterized by multidisciplinary teams of researchers. Teams that work across disciplines are often shown to publish more frequently, with greater scientific influence, and can be effective at producing more novel innovations.[iii] This is also critical for what's known as convergent research, in which existing disciplines combine to produce promising *new* fields, as is the case in synthetic biology. It seems the nexus between disciplines is fertile ground for creative thinking. Lastly, national challenges are often addressed obliquely, from scientific directions one wouldn't necessarily expect to be related. For example, longtime investments in computer science and high-performance computing at the Department of Energy are contributing to the science of genomics, which in turn could improve health outcomes for our nation's veterans.[iv]

Why is this important to our economy?

Our own Golden Goose Award, which honors federally funded research that has an unexpected and significant impact on society, showcases several ways in which innovation has enabled the economy to grow. An array of technologies that have provided positive economic and societal impacts — such as the laser, internet browsers, the eradication of livestock-destroying pests, and a concept called "fuzzy logic" that spurred thousands of patents and improvements to widely used technologies — can be directly traced to federal investments in research and development. The appendix of this testimony lists the economy-boosting outcomes of these and other stories.[v]

The federal government should also be creating opportunities and incentives to build geographic diversity in science, technology, engineering, mathematics, and medicine (STEMM). For instance, the regional innovation hubs proposed by the Senate and House bipartisan innovation bills, USICA and America COMPETES, are compelling ideas that Congress must support. There are several examples of how federal investment in STEMM can bolster state and local economies. Many of the National Labs provide information about economic impact to their states. The Los Alamos National Laboratory, to cite one example, released a report last year showing 117 projects performed in conjunction with 174 New Mexico small businesses with more than 500 jobs created or retained.[vi] And a 2020 economic report on NASA found impacts in all 50 states, particularly those with NASA facilities. [vii]

The contributions of federal R&D to broader geographic prosperity coincide with another vital national challenge: the need to shore up domestic supply chains. Last year, as part of their 100-day supply chain review, federal agencies identified R&D investment as one of several key actions to strengthen domestic production. Policymakers seem to have recognized the importance of semiconductor manufacturing, with the proposed $50 billion currently under discussion in the House and Senate bipartisan innovation bills. But the relevance of federal R&D extends to several other critical sectors as well, including advanced batteries, critical minerals, pharmaceuticals and biomanufacturing, biopreparedness, and the food supply, let alone the industries that make up the defense industrial base.

Invest in our people to ensure that we are drawing upon the talents of all Americans in our scientific research and that all Americans benefit from our investments.

To cure Alzheimer's and cancers, go to Mars, understand the fundamental laws of the universe and human behavior, develop artificial intelligence, and build a better future, we need the brain power of the descendants of Native Americans, Pilgrims, Founding Mothers and Fathers, Enslaved People, Ellis Island arrivals, and the most talented immigrants from everywhere. The United States has thrived as a crossroads where people are joined together by ideas and contribute by choice to the freedom and opportunity provided by this wonderful, inspiring, and flawed country that is always striving to live up to our aspirations.

The core of our nation's innovation ecosystem requires more than just funding. It relies on an investment in people — not just the scientists, engineers and mathematicians in our colleges, universities, industries, national labs, and biomedical facilities, but also the STEMM teachers, technicians, managers, financiers, patent attorneys, and more, whose collective efforts, grounded in science, fuel the nation's innovation economy. STEMM knowledge and skills are necessary for people throughout the workforce and across the spectrum of our society, from farmers utilizing weather data and robotics to cultivate and manage crops, to those who care for us when we are sick using previously unimaginable diagnostic tools. Investing in people means strengthening the very fabric of our society.

This is not a new concept. CEOs of major companies have understood this secret for the past decade, as outlined in a 2011 report by Forbes Insights.[viii] In an editorial published in one of our *Science* journals, serial inventor Joe DeSimone and Crista Farrell explored this concept further:[ix]

"Diversity that arises from ethnic, cultural, socioeconomic, professional, and experiential differences forms fertile ground for innovation. A successful scientific endeavor is one that attracts and cultivates diversity, draws upon its breadth and depth, and thrives on the creativity it sparks. …Thus, although convergence has been billed mainly as an integration of diverse disciplinary expertise from the life, physical, and engineering sciences, there is also the human factor to consider: how to leverage diversity among participants themselves."

Scientific excellence and achievement are inextricably linked to diversity of thought and experience. Talking about diversity can be a double-edged sword. When complementary talents and perspectives come together, leaps in understanding are more likely and disruptive technologies are born. But there is also a vulnerability. When seized upon to divide (with talk of quotas in a zero-sum game), diversity can be used to generate fear and stoke division in ways that increase inequities and stifle substantive debate. In the scientific enterprise, explicit acts of racism and sexism still exist and cause harm. However, it is often the less obvious factors — divisive rhetoric, obsolete policies (such as overreliance on standardized tests), and willful blindness to inequitable treatment (such as smaller startup budgets for female academics) — that cement many of the injustices that have sprung from the nation's segregated history. These opaque forces are so ingrained that we scarcely realize their implications for minorities and women in science.

Insisting on inclusion of underrepresented groups neither sacrifices scientific excellence nor diminishes the accomplishments of those who have historically dominated the sciences. Put another way, highlighting the previously hidden does not invalidate the already admired. But this change requires that the scientific community increase attention and support for those who have been disadvantaged. At the same time, we must recognize we are operating with powerful social constructs with societal consequences that cannot be overlooked. When we provide inputs to algorithms, when we write software, when we design studies and recruit participants, we are making human choices. It matters who is at the table when those choices are made. We need as wide an aperture as possible to ensure that science has maximum benefit for society. Avoiding these conversations amounts to advocating for the status quo — and the United States would be weaker for it.

The idea of a wider aperture is reflected in the fact that last year the National Science Board and National Center for Science and Engineering Statistics (NCSES), which produce the *Science & Engineering Indicators*, broadened their definition of workers in science, technology, engineering and math to include those with at least a bachelor's degree as well as workers without a bachelor's degree, which incorporates skilled technical workers.[x] There are different ways of looking at this. According to a survey by Science is US, which is housed at AAAS, two thirds of U.S. jobs are supported by science, tech, engineering and math, and the majority of that workforce does not hold a four-year degree.[xi] The need for a broad, inclusive STEMM workforce is clear.

As a nation, we need to cultivate meaningful partnerships between elite research institutions and those with limited resources, between industry and academia, and between government and the institutions that conduct research and train the next generation of STEMM professional across a wide spectrum of sectors.

The reasons for ensuring the diversity of science transcend the obvious moral imperative. Diversity of thought derived from diversity of experience gives America a critical advantage in the global competitive landscape. It is key to making the discoveries that will improve everyone's health, inventing the technologies that will grow the economy, and meeting the formidable challenges of this era. Without the innovative boost from a diverse population, the United States will be hard-pressed to compete on sheer numbers of scientists and engineers.

Balance a portfolio of R&D investment that includes short-term incremental research, translational research, and high-risk, high-reward research that if successful can change everything.

There is some evidence that the way we fund science is increasingly risk averse.[xii] There are likely a variety of reasons the funding system may tend toward safer bets and incremental advances. In the worst-case scenario, these tendencies crowd out projects with game-changing upsides if they succeed, because the odds for failure are also high: such is the nature of high-risk, high-reward research. To broaden our search for breakthroughs and give scientists the flexibility and freedom they need, the federal government should actively pursue a broad portfolio of research projects with varied risk profiles. Several good models for funding high-risk but potentially revolutionary research already exist and have been implemented in the U.S. or elsewhere around the world, alongside more traditional funding models.[xiii] We should learn from these efforts wherever insights can be had, and scale what works.

Investments in critical areas, such as semiconductor chip manufacturing via the CHIPS Act, are emblematic of the short-term investments that will yield important economic benefit and good jobs — while ensuring our security and the security of our supply chains. Basic research funded by the NSF, NIH, DOE, USDA, and elsewhere provides the longer-term seed corn for future breakthroughs. Translational research funded by the NIH, DOE, DOD, and others moves discoveries from the laboratory toward products and benefits for society. High-risk, high-reward research like that funded by DARPA and ARPA-Energy have the potential to be game-changers. The newly created ARPA-Health and ARPA-Infrastructure have the potential to break new ground in health and physical infrastructure.

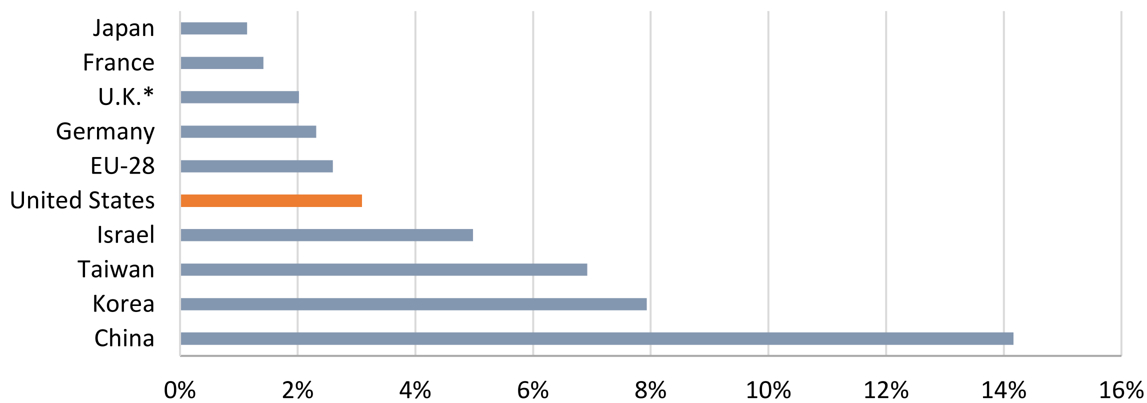
Crucially, many of these ideas about risk, translation, and breakthroughs are wrapped up in the new NSF technology directorate, authorization of which is currently under consideration as part of the bipartisan innovation legislation. While there are differing visions for this new office, what they have in common are emphases on new and varied ways to fund science, a focus on the translation of basic science from lab to market, and an investment in novel approaches to expand the regional map of innovation. The potential of this new directorate should be another strong motivator to complete negotiations on this legislation.

Our global competitors have also recognized the possibilities of robust investment in ideas and talent.

While we make these types of investments, the world is not standing still. Many nations have seen the benefits of all these models and are copying them with success. Earlier, I referenced a study from scientists at Fermilab that might change our fundamental understanding of physics and open up entirely new fields of discovery. The instrument where that data was collected was decommissioned several years ago. The verification of the result will have to come from the cutting-edge instruments of today, which are based in Europe and Asia and not in Illinois.

In the last 20 years, U.S. R&D expenditure from all sources has only grown at a rate of 3.1% annually, in constant prices. This investment has been eclipsed by the meteoric 14.3% annual rise of China's R&D expenditure over the same period, as well as more robust investments by Korea, Taiwan, and others. This means that while the U.S. remains the largest funder of public and private R&D, others have closed the gap. The U.S. accounted for 39% of global R&D in 2000, but today the share has fallen to 30%.

Figure 1: Annual Real Growth in R&D Expenditures 2000-2020



*UK data is based on 2019, latest data provided
Including public and private sources. Analysis based on OECD S&T Indicators data | AAAS

There's also been robust growth in venture capital, a key ingredient for financing and commercializing innovative technologies. The U.S. has well-entrenched long-term dominance in VC investment, and American venture capital continues to set new records. But over the past decade, Chinese VC investment has increased by an order of magnitude, and VC investments in both China and Europe have surpassed $30 billion in three of the past six quarters. This is not to say that U.S. leadership in this metric is threatened, but it does indicate the continued expansion of innovation economies overseas.

Beyond investment, the innovation economy also needs talent. The U.S. has one of the largest research workforces in the world, but it has already been surpassed by China in total researcher headcount. Several other economies have seen more rapid workforce growth as well: for instance, Germany and Korea have seen their respective number of researchers increase by 28% and 24% over the past five years, versus U.S. growth of 18%. Around the world, this workforce expansion is happening in both business and academia, underscoring the importance of a diversified workforce – not only in individuals but also in sectors.

Aggressive financial and human capital investment is helping others translate science into inventions, products, and processes. These can be measured using a metric known as “triadic patents,” or patents for the same invention filed in the United States, Japan, and Europe. In 2018, the latest year for which data is available, U.S. applicants filed for 18% fewer triadic patents than in 2000, as compared to Korea’s 138% increase over the same time period, and China’s whopping 6018% increase.

This does not mean that the United States is not a powerful engine for innovation. American inventors still dominate the biotech, medical, and nanotech patenting space, and are only beaten by Japan in information and communication technology and environmental technology patents. Still, our competitiveness needs to be actively maintained.

No nation on earth is more responsible than the United States for getting us to the cusp of inflection points in so many scientific disciplines — inflections points that could create step changes in economic growth and human well-being. The decisions we make today on where and how to invest will determine whether we will make the discoveries and translate the science into health and prosperity — or someone else will.

While other nations may invest and challenge U.S. competitiveness, I still find myself optimistic and hopeful. The United States is in an enviable position. We have capital, and we have research infrastructure. Now we need to light the fire by making some strategic bets as a nation, investing in those areas we know are going to be a part of the future, and investing in people to help us get there. Thank you for the opportunity to testify today. I stand ready to work with you and look forward to your questions.

APPENDIX

Golden Goose Awardees — Examples of Enhancement of the Economy

- Funding from the National Science Foundation and Office of Naval Research enabled the invention of the laser, which was born out of the seemingly obscure technique of amplifying waves of radiation into an intense, continuous stream. Now, laser technology enables many industries essential to the U.S. economy, from production of transportation equipment to the biomedical sector. The market for laser processing, which is used in manufacturing, was worth $11.8 billion globally and $2.8 billion in the U.S. in 2020.
  - https://www.reportlinker.com/p05798980/Global-Laser-Processing-Industry.html?utm_source=GNW

- National Science Foundation funding for supercomputing projects modeling collisions of black holes led to the creation of the first internet browsers. In 2020, the internet contributed $2.45 trillion to the U.S.'s $21.18 trillion GDP.
  - https://www.iab.com/news/study-finds-internet-economy-grew-seven-times-faster/

- Research funded by the Agricultural Research Service on a novel pest control technique — which involved understanding the sex life of the screwworm fly — led to the eradication of the deadly fly in North and Central America and saved the U.S. billions of dollars. In 1996, avoiding losses associated with the fly yielded economic benefits of $796 million to livestock producers and $2.8 billion to the U.S. as a whole (not adjusted for inflation).
  - https://www.aphis.usda.gov/animal_health/emergency_management/downloads/rrg_econimpact-nws.pdf

- Researchers funded by the National Institutes of Health massaged infant rats to develop a technique that has saved the lives of hundreds of thousands of premature babies and resulted in about $4.7 billion dollars in hospital cost savings each year due to shorter stays in the NICU.
  - https://srcd.onlinelibrary.wiley.com/doi/abs/10.1002/j.2379-3988.2004.tb00024.x

- Research funded by the National Institutes of Health and Air Force Office of Scientific Research that focused on how cats' eyes respond to dots moving on a screen resulted in a treatment for congenital visual impairments like cataracts. The research also paved the way for the machine vision industry, which allows computers to process images like humans; the industry is growing very quickly and was valued at $13.23 billion in 2021.
  - https://www.grandviewresearch.com/industry-analysis/machine-vision-market

- Researchers granted funding from the National Science Foundation and Office of Naval Research studied the foraging behavior of bees and their communication via a "waggle dance" to create an algorithm that has streamlined internet services for consumers and maximized revenues for web hosting services, a market estimated in 2021 to be worth $30 billion in the U.S. alone.
  - https://www.marketresearch.com/Global-Industry-Analysts-v1039/Web-Hosting-Services-30864413/

- The mathematical concept of “fuzzy logic,” developed by a researcher with funding from the National Science Foundation and Air Force Office of Scientific Research, has spurred over 16,000 patents and improvements in fields ranging from HVAC systems to voice recognition software, a field that generated $2.9 billion in North America in 2018.
  - https://www.fortunebusinessinsights.com/industry-reports/speech-and-voice-recognition-market-101382

- Researchers studying game theory with funding from the Atomic Energy Commission, National Science Foundation, and Office of Naval Research solved the FCC’s immense challenge of allocating the nation’s telecommunication spectrum via sophisticated, enormously complex auctions. The FCC has conducted 87 spectrum auctions and raised over $60 billion for the federal government, while facilitating the ability to make cell phone calls from anywhere in the country, watch cable TV, find a restaurant anywhere in the world, and livestream the “big game” from a smartphone.
  - https://www.goldengooseaward.org/01awardees/auction-design

Sudip S. Parikh, Ph.D.

Chief Executive Officer and Executive Publisher, Science Journals
American Association for the Advancement of Science (AAAS)

Sudip Parikh, Ph.D., became the 19th chief executive officer of the American Association for the Advancement of Science (AAAS) and executive publisher of the Science family of journals in January 2020. Parikh has spent two decades at the nexus of science, policy, and business.

Immediately prior to joining AAAS, Parikh was senior vice president and managing director at DIA Global, a neutral, multidisciplinary organization bringing together regulators, industry, academia, patients, and other stakeholders interested in healthcare product development. He led strategy in the Americas and oversaw DIA programs that catalyzed progress globally toward novel regulatory frameworks for advanced therapies not amenable to existing regulations.

Prior to DIA, Sudip was general manager of the Health and Consumer Solutions business unit and vice president at Battelle, a multibillion-dollar research and development organization. He led a $150 million business unit with over 500 scientific, technical, and computing expert performing basic and applied research, developing medicines and healthcare devices, and creating advanced analytics and artificial intelligence applications to improve human health. Previously, Parikh led Battelle’s global AgriFood business unit. Headquartered in London and Geneva, this unit provided environmental fate research and agriculture product development services from laboratories throughout Europe and the United States.

From 2001 to 2009, Parikh served as science advisor and professional staff to the United States Senate Appropriations Committee, where he was responsible for negotiating budgets for the National Institutes of Health (NIH), Centers for Disease Control and Prevention, Agency for Healthcare Research and Quality, Biomedical Advanced Research and Development Authority, and other scientific and health agencies. A key legislative liaison to the research and development ecosystem, Parikh was on the frontlines of many science policy issues debated during that time, including embryonic stem cell research, cloning, disease surveillance, bioterrorism, cyber security, and doubling the NIH budget.

An active member of the scientific advocacy community, Parikh serves as a board member and officer for several impactful organizations, including Research!America, Friends of Cancer Research, and ACT for NIH. He has received multiple public service awards, including recognition from the American Association of Immunologists, the National AIDS Alliance, the Coalition for Health Services Research, and the Juvenile Diabetes Research Foundation.

Sudip is committed to early STEM education and, as a parent of three energetic young children, he prioritizes volunteering as a mentor for Science Olympiad teams at two elementary schools. Early in his career, Parikh was a Presidential Management Intern at the NIH. He was awarded a National Science Foundation Graduate Research Fellowship while earning his Ph.D. in macromolecular structure and chemistry from the Scripps Research Institute in La Jolla, Calif. There, he used structural biology and biochemistry techniques to probe the mechanisms of DNA repair enzymes bound to DNA. The son of Indian immigrants who worked in the textile and furniture manufacturing plants of North Carolina, Parikh completed undergraduate studies at the University of North Carolina at Chapel Hill, first as a journalism major before switching into materials science.

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[i] https://sciencetechaction.org/
[ii] https://www.science.org/content/article/mass-rare-particle-may-conflict-standard-model-signaling-new-physics
[iii] https://psycnet.apa.org/doiLanding?doi=10.1037%2Famp0000319
[iv] https://blogs.va.gov/VAntage/37500/va-partners-with-department-of-energy-on-big-data-initiative-to-improve-health-care-for-veterans/
[v] https://www.goldengooseaward.org/
[vi] https://cdn.lanl.gov/files/Los%20Alamos%20National%20Laboratory%20-%202021%20Economic%20Impact%20on%20New%20Mexico.pdf
[vii] https://appel.nasa.gov/2020/10/15/report-quantifies-nasas-far-reaching-economic-impact/
[viii] https://images.forbes.com/forbesinsights/StudyPDFs/Innovation_Through_Diversity.pdf
[ix] https://www.science.org/doi/full/10.1126/scitranslmed.3004486
[x] https://beta.nsf.gov/science-matters/measuring-progress-and-gaps-us-skilled-technical-workforce
[xi] https://scienceisus.org/stem-supports-two-thirds-of-us-jobs/
[xii] https://www.nber.org/papers/w28905
[xiii] https://www.oecd.org/sti/effective-policies-to-foster-high-risk-high-reward-research-06913b3b-en.htm