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Chairman Neal, Ranking Member Brady and Members of the Committee,

Thank you for inviting me to testify today on this critically important subject. I will focus my remarks on competition. My fundamental message is straightforward: Whatever else the U.S. does to counter the challenges posed by China, we must increase our investment in research in key technology areas, and we must enhance our capacity to get the most out of that investment. U.S. strategy is unlikely to succeed if it is merely defensive; to stay ahead, the U.S. needs to do more to capitalize on our own strengths.

To understand the risk of failing to develop and implement such a strategy, one need look no further than the field of advanced communications, particularly 5G. The U.S. failed to invest adequately in this technology, and now we are having trouble catching up, ceding markets to Huawei and others, and fretting about the possible security consequences.

We need to reorient our thinking to be sure that we do not underestimate China. Specifically, we should not lull ourselves into believing that China's rise is being fueled solely by stealth and subterfuge. Illicit and improper Chinese activities must be stopped, but we also need to recognize that China now has internal strengths in key fields, such as artificial intelligence (AI). China is making substantial investments in its own research and researchers, as well as in commercialization. The U.S. needs to plan accordingly.

I believe our strategy needs to have three elements – first, a visible, focused and sustained research program targeted at technologies that are critical to future U.S. prosperity and security, like AI and quantum computing. Second, a concerted effort to ensure the U.S. has the talent we need to stay ahead. And third, policies to accelerate the U.S. capacity to get new ideas into the marketplace. Let me speak briefly about each of these.

The U.S. has extraordinary research capability; we are home to most of the world's top research universities. That's why others want to steal our ideas. But our research system is not optimized for our current challenges, with other countries pouring money into select fields under programs like Made in China 2025.

The Made in China 2025 program has a far broader scope than just research, but the Chinese government clearly sees research as a central element in becoming the world leader in key industries. In AI, for example, estimates of Chinese investment vary widely, but even the most conservative estimates find China at least at spending parity with the U.S. and committed to becoming a leader in the field.

According to the National Science Board, overall Chinese spending on research and development (R&D) probably surpassed that of the U.S. in 2019 for the first time. That does not mean, by itself, that China's research is as good as ours or is effectively targeted, but it is a sign of trouble ahead, if we allow current trends to continue. And money is not the only disturbing indicator. A study last year of AI publications found that China is approaching parity with the U.S. in producing high-impact AI research papers. (China already surpasses the U.S. in the total number of AI papers.)

Losing our technological lead would damage the U.S. militarily, as well as economically, since the military increasingly relies on technical advances in the commercial sector. Numerous studies have underscored this point, including, "Innovation and National Security: Keeping Our Edge," a report from a task force of the Council on Foreign Relations, in which I participated. (https://www.cfr.org/report/keeping-our-edge/).

Simply put, federal research funding has fallen far behind what's needed to stay ahead of our competitors. Constraints on federal discretionary spending have made it impossible to invest at necessary levels. Federal non-defense R&D spending has hovered at between 10 and 12 percent of overall non-defense discretionary spending for more than 35 years, and it has declined as a percentage of Gross Domestic Product. When we felt most threatened by the Soviet Union in the early 1960s, that percentage peaked at about 25 percent.

Spending figures underscore only part of the problem. The U.S. also lacks an effective, coordinated strategy to target research toward specific areas. To develop and implement such a strategy, it may be necessary to rethink how the U.S. research system is organized and focused.

I just came from speaking at a National Academy of Sciences event organized to commemorate the 75th anniversary of Vannevar Bush's report, *Science: The Endless Frontier*, which is considered to be the founding document of the post-war U.S. science establishment. Bush, who ran U.S. scientific efforts during World War II, looked into the future and recognized that the federal role in research needed to change, if Americans were going to gain the full benefits of scientific advancement. Thanks largely to Bush, new science agencies were created after the war; existing agencies expanded and thrived. And that contributed to the postwar advances in U.S. prosperity, security and well-being.

In a similar fashion, we need to think more about what kind of federal bureaucracy and policies are needed to meet today's needs and those of the future.. I believe a portion of federal research funding should be focused on addressing far-reaching questions in key technology fields, like AI. One promising proposal is to create a new directorate at the National Science Foundation with that mission – identifying key technologies and directing fundamental research to those areas – and giving that new unit the authority to be run more like the Defense Advanced Research Projects Agency (DARPA). The directorate could provide funding to other agencies, as well as to universities and consortia involving industry.

When witnesses were asked about this idea at a January 29 hearing of the House Science Committee, all responded positively. The witnesses were former Google CEO Eric Schmidt, National Science Board Chair Diane Souvaine and Chaouki Abdallah, the executive vice president for research at the Georgia Institute of Technology.

I should emphasize that I am talking about fundamental research problems, not narrower applied research. An example would be creating AI algorithms that would enable machines to learn with less data. That fundamental advance would eliminate a Chinese advantage. Today, AI requires massive amounts of data, and that gives the Chinese an edge – both because they have a larger population and because they have fewer legal constraints. Take away the need for so much data, and that Chinese advantage vanishes. Working on such problems is different from just further perfecting the algorithms we have now. It's the kind of leap-frog research most likely to be done at universities.

I know there is a growing recognition in Washington that more funding and more focus are needed to keep the U.S. ahead in key research areas. I have been delighted to see recent proposals from the Administration, and from members of both parties, on both sides of the Capitol, to increase U.S. research to advance our competitiveness. But so far this has not translated yet into real funding of the scale and scope that is needed, and funding should not come from making deep cuts in our existing scientific investments.

To make research strides, the U.S. needs more than cash, it needs talented researchers. At the university level, that requires two parallel tasks -- attracting top U.S. students to key fields; and attracting and retaining the best researchers from around the world. The federal government should be offering scholarships, traineeships and fellowships aimed at drawing U.S. undergraduates, graduate students and post-docs into the fields where we need them most – the key technology areas I've been citing.

But the U.S. has never succeeded solely with domestic talent; we need to reach beyond our borders. The vast majority of students who come to the U.S. for their doctorates in science and engineering remain here -- but we make that difficult, and the percentage who stay has been declining.

The latest statistics from the National Science Board show that foreign students account for more than half the U.S. doctoral degrees in engineering, mathematics and computer science, with more than half of those foreign students coming from China, India and South Korea. This is not a new situation. What is new is that fewer of them are staying – although most still remain. NSF found that 84 percent of the doctoral students from China were still in the U.S. five years after receiving their degree. As I've said, we need to get more U.S.-born students into these fields, but even when we succeed at that, attracting and retaining top students from overseas will still be a necessity.

To keep top talent, we need to look at changing both our policies and our rhetoric. The U.S. should be offering green cards as a matter of course to those who complete advanced studies in our country. We also need to understand that anti-immigrant rhetoric and widespread visa delays cause all students and researchers to consider taking their talents elsewhere. The federal government must appropriately vet those coming to our nation to avoid security risks, but that should not be done in a way that unduly deters those we want and need here.

Leading in research is a necessary but not sufficient condition for prosperity and security. We also have to be the best and the fastest at translating ideas into products and processes. That's not something that can be accomplished by closing off our system – that just would shut down intellectual exchange that benefits us. We need instead to improve our ability to turn intellectual success into commercial success.

China is becoming better than the U.S. at getting novel ideas into commerce. We cannot copy their means of doing that, which involve massive and probably wasteful government subsidies and indifference about intellectual property protection among Chinese companies, among other things. We need here, too, to capitalize on our own strengths, such as the U.S. ability to spin out companies from university labs. But more of those enterprises need to survive past infancy. That will require policy experimentation.

Those experiments should be geared toward two related goals – finding additional ways to de-risk technology so it is ready for the marketplace, and making more U.S. capital available to support new ventures for long enough that they can thrive.

The federal government could help foster through planning grants and pilot programs to answer questions like these: Do we need new legal entities to enable spin-off companies to stay more connected to campus for a longer period so the technology can mature to the point where it has more chance of success when venture capitalists back it? Do we need better training and mentorship so that technical people have the business acumen to get their companies through the "valley of death"? Do we need funds to help more entities like The Engine (https://www.engine.xyz/), which MIT has started to enable new companies to get access both to capital and technical expertise? Do we need supplements to research grants to enable researchers to start figuring out earlier how they would navigate the private sector? Those are just some possible approaches.

This Committee may have a role to play because tax policies might be used to create more patient capital, which is needed to avoid killing promising ideas in the cradle. Could tax policies create incentives to encourage a longer-term perspective when funding new ventures? Could tax policies help make available additional U.S.-based capital for start-ups, so they don't have to look overseas for financing? Could tax incentives encourage new kinds of cooperation between universities and industry? These are the kinds of questions that need to be explored if competing with the China is truly a U.S. priority.

The U.S. edge in science and technology has been a foundation for U.S. security, prosperity and quality of life. But that edge has to be regularly honed; it is not ours by right or by nature. We can best sharpen it with a strategy founded on confidence in ourselves, not fear of others.