Statement before the

House Committee on Science, Space, and Technology

"U.S. Competitiveness with the People's Republic of China in Research and Development."

A Testimony by:

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Cisco WebEx

Chairwoman Johnson, Ranking Member Lucas, and members of the Committee, I am honored to appear before you to discuss America's competitiveness in science and technology, particularly as relative to the People's Republic of China. With your permission I will submit a statement for the record and briefly summarize it for this hearing.

My remarks draw heavily on a report entitled, "The Perils of Complacency" that was prepared by a group of 25 leaders in a variety of fields under the aegis of the American Academy of arts and Sciences, now nearly 250 years old, and the Rice University Baker Institute of Public Policy. You had asked that I briefly comment on implications of ongoing trends in competitiveness as they affect national security. I should emphasize that my observations on that specific subject will be my own, since our group did not specifically focus on national security.

The thrust of my message today is fairly straightforward. First, America's overall wellbeing is fundamentally dependent on maintaining a strong economy. Second, maintaining a strong economy is fundamentally dependent upon advancements in science and technology. Third, America is on a path to lose its lead in science and technology to China.

China clearly understands the importance of science and technology. For example, this is what Wen Jiabao, former Premier of the State Council of the People's Republic of China had to say on the subject:

> "The history of modernization is in essence a history of scientific and technological progress. Scientific discovery and technological inventions have brought about new civilizations, modern industries, and the rise and fall of nations…I firmly believe that science is the ultimate revolution."

The Premier's perspective should not be particularly surprising inasmuch as a large segment of China's leadership in recent decades has been composed of scientists and engineers. In its Fourteenth Five-Year Plan, China has made it clear that it intends to assume global leadership in science and technology and to do so in the near future.

Change happens rapidly in science and technology. The number of transistors on a microchip has increased by a *factor* of 10 million over the past 50 years. The cost of reading a human genome dropped by a *factor* of 10 thousand over the past 13 years. Solar panel prices have been reduced by a factor of 100 million over the past 15 years. The first iPhone was introduced only thirteen years ago, yet today half the people on the planet, 3.5 billion people, now possess one. And a year and a half ago most Americans had never heard of COVID-19, while today new vaccines have been developed and nearly 200 million doses administered.

To lag behind the state of the art in science and technology is to risk falling out of the race altogether. We live in a golden age in science and technology, rich with opportunities spanning from artificial intelligence to quantum science, from genomics to robotics, and those who lead in discovery will lead in the opportunity to generate applications. And we have the good fortune to live in a highly dynamic economy that rewards innovation.

Further, many of the major challenges our nation faces today will likely find their solutions in science and technology. These include preserving our climate, rebuilding our infrastructure, reducing the cost of healthcare, protecting against future pandemics, securing our electric grid, and providing national defense.

My first trip to China was in 1978, and as I traveled thousands of miles around the country I saw only a handful of automobiles. *Every* adult was wearing a Mao suit. In my return trips over the years I have been astonished by what China has accomplished, including in science and technology. Which is not to say that I endorse many of their approaches. But what I have seen seems to serve as a warning—a “Sputnik Moment,” if you will. But I fear that in recent years we have been more akin to frogs being slowly boiled.

A number of studies, two of which were recognized with Nobel Prizes, have shown that up to 85 percent of the growth in the U.S. economy in recent decades can be attributed to advancements in just two closely related fields: science and technology. It is, of course, our economy that makes it possible to pay for national security, social security, healthcare, infrastructure, homeland security, education, biomedical, and much, much more.

It has become fairly common to compare the financial investments of the U.S. and China in various endeavors, say R&D or national security, using standard market exchange rates. I would assert that such comparisons are often misleading. They spawn such conclusions as “the U.S. spends far more on its military than China and Russia combined…and therefore the U.S. must have a far greater military capability.” As but one example of the problem with this line of thought is that, unlike China, the U.S. seeks to pay those who serve in its voluntary armed forces a wage matching that which they might receive in a “comparable civilian job”—presuming that there *is* a comparable civilian job wherein one is on duty 24 hours a day, expected to leave one’s family for years at a time, and can fully plan on being shot at during the course of their career. This difference in the cost of manpower is one element that explains how China affords a military force of 2.8 million members while that of the U.S. is about 1.2 million.

A second measure of comparison is spending as a percent of GDP, which can be useful in assessing the financial burden imposed on a nation by any particular investment, say in R&D. It can also be indicative of the emphasis a nation places on a particular activity. Arguably, still more meaningful comparisons can be made using exchange rates at purchasing power parity as a measure—which is the principal comparator used in the "Perils of Complacency" report. While an imperfect measure, it does indicate quite clearly that China has been steadily gaining on the U.S. in effective investment in R&D and can be expected to pass the U.S. by this measure in the next few years—assuming decades long policies continue to prevail in both nations.

China is already leading the world or is highly competitive in many critical fields of technology, including solar cells, energy storage, supercomputers, artificial intelligence and 5G communications.

But beyond the provision of financial resources for a nation's R&D pursuits, there is a second arguably more important factor that drives advancement in these fields: human resources. China now graduates from its universities over twice as many baccalaureate engineers as does the U.S. from its universities. This should be no surprise, given that China's population is four times that of the U.S. In fact, China passed the U.S. in the number of newly awarded science and engineering doctoral degrees some 15 years ago. The U.S. cannot hope to match the number of scientists—or soldiers—marshalled by China; rather, the U.S. must compete based upon innovation, entrepreneurship, creativity, allies, and efficiency of generating new knowledge and translating that knowledge into applications.

In China over half of baccalaureate degrees are awarded in STEM (science, technology, engineering, and mathematics) fields, whereas the comparable figure in the U.S. is 19 percent. Forty percent of K-12 students in the U.S. are underrepresented minorities that ultimately receive only 7 percent of the doctorates granted in STEM fields. Women receive 58 percent of U.S. undergraduate degrees, yet receive only 17 percent of the doctorates awarded in the U.S. in the natural sciences and engineering. The U.S. could vastly increase its number of contributing scientists and engineers were it simply to attract representative portions of all its domestic groups into the STEM fields.

In the most highly regarded international test of student performance, the PISA test, U.S. fifteen-year-olds rank 25th among 29 developed nations in combined science, mathematics and reading score. By America's own measure of achievement, the so-called "Nation's Report Card," 67 percent of fourth graders are categorized "not proficient in science." By 12th grade that share increases to 79 percent. Ironically, we spend more per pre-K-12 pupil than any other country but one. Having traveled in 130 countries and visited many schools, I find reason to share Bill Gates' observation that "When I compare our high schools to what I see when I am traveling abroad, I'm terrified for our workforce of tomorrow."

Perhaps America's most significant competitive advantage in science and technology is its collection of world-class research universities, generally considered to comprise all of the top five and 40 of the top 50 such institutions in the world. However, U.S. states recently cut funding of their universities that educate 70 percent of our college students by an average of 25 percent in real dollars during the Great Recession, making many universities quasi-private institutions…without adequate endowments. In more recent years, modest steps were taken to recover a moderate part of that lost funding. Additionally, the federal government imposed an (initially relatively modest) tax on the growth in endowments at a few of our nation's most highly regarded research universities, thereby absorbing funds that would otherwise have been available for scholarships and research—all while discouraging potential future donors to endowment funds.

How, then, has the U.S. been able to maintain such a strong competitive position in so many STEM fields in the past? A significant part of the answer resides in the fact that today's U.S. science and engineering enterprise would barely function were it not for the thousands of foreign-born individuals who came to America, received their graduate education here, raised their families here, and contributed mightily to our nation's science and engineering community.

Seventy-three percent of graduate engineering students at U.S. universities are foreign-born, as are 28 percent of science and engineering faculty, along with half of the post-doctoral workers who perform much of the nation's scientific research. Thirty percent of the overall science and technology workforce in America was foreign-born, and nearly half of the nation's Fortune 500 companies were founded by immigrants or the children of immigrants. Thirty percent of US. Nobel Laureates in the sciences were foreign-born, as were 26 percent of the individuals elected to membership in the U.S. National Academy of Sciences and 31 percent of those elected to the National Academy of Engineering.

It is vitally important that more of America's youth be motivated and qualified to pursue careers in science and engineering; yet, without continuing to attract talent from around the world there is little chance that America can remain competitive. By my calculation, were America to need one additional person performing research in the field of engineering in the year 2034, it would need to begin with a group of 3,000 eighth graders today.

Were one to create a "report card" assessing the extent of America's commitment to global leadership in science and engineering, it would look something like the following:

- Quality of research universities – 1st;
- Investment in R&D at purchasing power parity – narrowly 1st;
- Innovation – dropped from 1st to 8th;
- R&D as a percent of GDP – dropped from 1st to 10th;
- Primary and secondary education – 25th;
- Professionals in R&D, per capita – 28th;
- Fraction of research funded by government – 29th;
- Fraction of initial degrees awarded in engineering – 76th (just behind Mozambique).

I have been asked to comment on the implications of these trends as they pertain to national security. I would merely cite two factors: first, the history of warfare has been punctuated by balance-tipping technological breakthroughs: the stirrup, the longbow, gunpowder, the cannon, machine guns, tanks, battleships, aircraft, nuclear weapons, rockets, night vision, stealth, space, robotics, autonomy, cyber, and more. An example of the impact that technological dominance can have when accompanied by trained, well-led troops was to be seen during the first Gulf War when the Allied forces defeated the fourth largest army in the world in just 42 days. U.S. fatalities totaled 219.

Second, an often-overlooked factor is that in the past most advancements in defense technologies came from military arsenals; today most come from commercially available pursuits such as automation, artificial intelligence, advanced microchips, and soon, quantum science. It will be increasingly difficult to isolate critical defense technology from the world at large—leadership will be the sine qua non.

The "Perils of Complacency" report offers a number of specific recommendations to ensure America's competitiveness well into the future, as did the earlier National Academies "Gathering Storm" report. Were I to heavily summarize those recommendations they would be to fix our nation's pre-K-12 public school system, particularly in STEM, and substantially increase federal investment in high payoff, generally high risk, research—primarily conducted at our universities.

Finally, if you will permit a moment's personal reflection, I am now 85 years old and likely won't be around to witness the ultimate outcome of whatever decisions are made today in America and China. It would be my hope that in America we will recognize that we can no longer compete in R&D based on past investments but will have to substantially increase our commitment to people and funding.

Earlier in my career as an aerospace engineer, I had the occasion to play a very tiny role in placing twelve people, most of whom were to become my friends, on the moon. I found it truly inspiring what our nation could do when we put our minds to it.

Thank you.