TESTIMONY OF
Michael S. Teitelbaum
Vice President, Alfred P. Sloan Foundation

before the
Subcommittee on Technology and Innovation
Committee on Science and Technology
U.S. House of Representatives
Washington, DC
November 6, 2007

Mr. Chairman, Members of the Subcommittee, Ladies and Gentlemen:

Thank you for inviting me to share with you my thoughts on the fascinating questions you and your staff have raised regarding the U.S. science and engineering workforce, and the implications of globalizing R&D for its future dynamism and productivity.

By way of introduction, I am Vice President of the Alfred P. Sloan Foundation in New York, a philanthropic foundation created in the 1930s that has long devoted substantial funding to improving the health of U.S. science, engineering, and economic performance. Over the past few years, the Sloan Foundation has supported a number of research projects and data collections by leading analysts that address your questions. At a personal level, I should add that I am myself a demographer who has spent a good deal of time in recent years examining some of the questions you are raising. Twenty-five years ago I served as the Staff Director of the Select Committee on Population of this House. Today I am appearing before you in my personal professional capacity. The Sloan Foundation as an institution takes no positions on these issues.

Others on the panel will address the forces underlying globalization and possible future trends. In the short time available to me, I will focus on what we are <u>often told</u>---as distinct from what we <u>actually know</u>---about the sufficiency of the U.S. science and engineering workforce for the current and future R&D enterprise, and I will also offer some more speculative comments on the possible impacts of globalization trends.

The Conventional Portrait

Let me first, very briefly, summarize what I would call the Conventional Portrait. It will be very familiar to Members of this Subcommittee; I know you have had many witnesses before you who have put forward such views. The Conventional Portrait may be summarized briefly as follows:

<u>First</u>, there are serious <u>shortages</u> or <u>shortfalls</u> in the U.S. of scientists and engineers --- either current shortages/shortfalls, or “looming” ones --- that bode ill for the creativity and competitiveness of the U.S. economy.

<u>Second</u>, the numbers of newly-educated scientists and engineers graduating from U.S. universities are reported to be insufficient for the needs of U.S. employers, even though the

science careers they are offering are growing rapidly and are attractive and well-remunerated. Some argue that it is this insufficiency that really compels U.S. high-tech firms to offshore increasing fractions of their R&D work, and to hire increasing numbers of scientists and engineers from abroad to “fill the gaps”.

Third, the argued insufficiencies of supply are due to the weakness (or even “failure”) of U.S. K-12 education in science and math.

Fourth, U.S. students are showing declining interest in science and engineering careers, even though these are growing strongly.

Fifth, the “postdoc” status found in growing numbers in most U.S. research universities offers an excellent training opportunity for young scientists before they enter into the promising academic research careers that lie before them.

Sixth, the Congress should respond to these realities by providing large government investments to increase the number of students completing majors in science and engineering fields, and in increasing the flow of Federal research dollars to these fields.

Two prominent examples of such portraits can easily be found in the 2005 report Tapping America’s Potential, led by the Business Roundtable and signed onto by 14 other business associations; and by the 2006 National Academies report Rising Above the Gathering Storm, which was the basis for substantial parts of what eventually evolved into the American COMPETES Act. The 2005 Tapping America’s Potential report called for an array of policies and expenditures to “double the number of science, technology, engineering, and mathematic graduates by 2015”, i.e. a 100 percent increase in 10 years. They were very forthright about this; this core goal appeared right on the report’s cover.

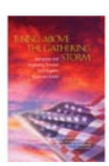
Typical report recommendations

Tapping America’s Potential (2005)

- More/better K-12 teachers
- More S&E undergrad/grad
  - More scholarships & loan-forgiveness at all levels
- More S&E immigrants
- More research funding

Rising Above the Gathering Storm (2006)

- More/better K-12 teachers
- More S&E scholarships
  - +25,000 4-yr undergraduate
  - +5,000 3-yr graduate
- More S&E immigrants
- More research funding
- Double R&D tax credit



The Realities

I have described such views as “Conventional”, but unfortunately that does not mean they are correct. <u>To the contrary, they are largely inconsistent with the facts</u>. The realities --- highlighted by the findings of most researchers who have addressed this subject with an open mind --- are very different from the Conventional Portrait; indeed in important ways they are almost the opposite. Here is a similarly brief summary of the findings from such research:

<u>First</u>, no one who has come to the question with an open mind has been able to find any objective data suggesting general “shortages” of scientists and engineers. The RAND Corporation has conducted several studies of this subject; its conclusions go further than my summary above, saying that not only could they not find any evidence of shortages, but that instead the evidence is more suggestive of surpluses. I would add here that these findings of no general shortage are entirely consistent with isolated shortages of skilled people in narrow fields or in specific technologies that are quite new or growing explosively.

<u>Second</u>, there are substantially more scientists and engineers graduating from U.S. universities that can find attractive career openings in the U.S. workforce. Indeed science and engineering careers in the U.S. appear to be relatively <u>un</u>attractive--- relative that is to alternative professional career paths available to students with strong capabilities in science and math.[1]

<u>Third</u>, students emerging from the oft-criticized K-12 system appear to be studying science and math subjects more, and performing better in them, over time. Nor are U.S. secondary school students lagging far behind comparable students in economically-competitive countries, as is oft-asserted.

<u>Fourth</u>, large and remarkably stable percentages of entering freshmen continue to report that they plan to complete majors in science and engineering fields; however, only about half of these ultimately do so.

<u>Fifth</u>, the postdoc population, which has grown very rapidly in U.S. universities and is recruited increasingly from abroad, looks more like a pool of low-cost research lab workers with limited career prospects than a high-quality training program for soon-to-be academic researchers. Indeed, if the truth be told---only a very small percentage of those in the current postdoc pool have any realistic prospects of gaining a regular faculty position.

<u>Sixth</u>, rapid increases in Federal funding for scientific research and education is more likely than not to further destabilize career paths for junior scientists. Under the current structure, the effect is substantial growth in “slots” for PhD students and postdocs to conduct the supported research, but only limited increases in the numbers of career positions (I will give you a concrete and large example in a moment).

There are many researchers and organizations that have developed this set of understandings of what is actually happening---for example: leading researchers at the Rand Corporation; Harvard University; National Bureau of Economic Research; Urban Institute; Georgetown University; Georgia State University; Stanford University; etc. I’ll be happy to provide your staff with a bibliography of the now-substantial body of research and analysis that comes broadly to this set of conclusions.

[1] There are many journalistic reports of senior scientists and engineers advising students, including their own children, not to pursue careers in these fields….

Why is the Conventional Portrait a Washington Perennial?

So why, you might ask, do you continue to hear energetic re-assertions of the Conventional Portrait of "shortages", shortfalls, failures of K-12 science and math teaching, declining interest among US students, and the necessity of importing more foreign scientists and engineers?

In my judgment, what you are hearing is simply the expressions of interests by interest groups and their lobbyists. This phenomenon is, of course, very familiar to everyone on the Hill. Interest groups that are well organized and funded have the capacity to make their claims heard by you, either directly or via echoes in the mass press. Meanwhile those who are not well-organized and funded can express their views, but only as individuals.

The interest groups that continue to make the Conventional case include:

- Some employers of scientists and engineers, and their industry associations [ample pools of qualified hires, without need to raise wages and benefits?]
- Some universities and university associations [graduate student enrollments and postdocs to conduct funded lab research?]
- Some funding agencies [credible argument for increased funding?]
- Some immigration lawyers and their associations [high-volume visas, with legal fees paid by employers?]

I want to emphasize that in making this case, none of these interest groups intend any harm to anyone. There is no evil intent, nor malevolence, nor exploitation. They are simply promoting their interests, as interest groups should be expected to do.

Yet there are few (if any) organized groups that represent the career interests of professional scientists or engineers---not to mention the future interests of people who are still students and who might, or might not, choose to pursue such careers.

So when you hear from interest groups about this range of subjects, you pretty much hear only from employers and their associations, universities and their associations, funding agencies, and immigration lawyers and their associations. There are exceptions to this, but they are few in number and often tightly constrained about lobbying you.

The Perverse Funding Structure for Science Graduate Education

Let me turn now to one of the perverse aspects of the way funding for science is currently structured. Given the short time available, I must simplify (I hope I do not over-simplify). Put simply, the way we currently fund graduate education in science is a recipe for instability, for enthusiastic booms followed by dispiriting busts. Let me illustrate by reference to NIH and the biomedical sciences.

Many of you may be aware that a large majority of biomedical PhD students and postdocs supported by NIH are financed by research grant funds, rather than by "training" or education funds. This was not the case 25 years ago, but it is now. This means that if NIH research funding is increased in response to too-low success rates for grant applicants, one effect is funding for more PhD students and postdocs who are recruited by NIH grant recipients to do the bench research work. This means that, after a lag of several years, there will be more recent PhDs and postdocs seeking research employment, and applying for NIH research grants. This in turn tends to reduce the grants success rate going forward.

Something exactly like this is now underway --- with a vengeance --- in the biomedical research sector. In part due to low and declining success rates, and special concern about the especially difficult experiences of younger scientists, Congress increased the NIH research budget by 100% in only the five years from 1998-2003---on the order of 14-15% annual increases. The absolute increase was also large: from \$13.6 billion to \$27.3 billion. If inflation is taken into account, the "real" percent and absolute increases were of course lower, but still very large.

Following the promised doubling, NIH budget growth has stagnated since 2003. The result is what many in the biomedical field are calling a "hard landing", and what others call a "funding crisis". Researchers are spending more and more of their time writing proposals, the stability of research careers is imperiled, and some labs face the prospect of closing down.

Much of what is now happening was not only foreseeable, but was actually foreseen. Dynamic modeling of the U.S. PhD and research funding systems undertaken by Goldman and Massy[2] at Stanford and Rand during the 1990s demonstrated (for all who cared to see) that:

- University departmental needs drive intake of PhDs (p. 20)
- PhD admissions are insensitive to external labor market conditions (p. 22)
- Simulations of five years of research funding growth at 2% per year followed by stable funding produces a short-term increase in employment for recent PhDs, followed within a few years by declines in employment for recent PhDs (pp. 42ff).

An unrelated but prescient article by prominent observers of the biomedical research scene, published by Science magazine in 2002, anticipated correctly what was to take place several years later, following the final 14% budget increase in 2003. The authors estimated that given the nature of the NIH biomedical research funding structure, continuous annual budget increases of at least 6-8 percent would be required to maintain stability and avoid serious negative consequences.[3]

One way to describe the system we have evolved is one with "positive feedback loops" built right into it --- unintentionally, to be sure --- a bit like a cockeyed thermostat that responds to rising temperatures not by shutting off the furnace but instead by calling for more heat. In all

[2] Charles A. Goldman and William F. Massy, The PhD Factory: Training and Employment of Science and Engineering Doctorates in the United States (Boston: Anker Publishing, 2001). The research on which this book was based was supported by a peer-reviewed grant from the Alfred P. Sloan Foundation.
[3] David Korn, et al., "The NIH Budget in the "Postdoubling" Era, Science, Vol 296, 24 May 2002, pp. 1401-1402.

systems analyses of which I am aware, positive feedback loops like this *tend toward unstable equilibria* --- if funding growth is rapid enough, one can readily foresee there will be boom first, followed by bust, unless rapid budget increases can be continued indefinitely.

One important lesson from the recent NIH case is that one of the fundamental goals of doubling the budget --- to increase success rate of proposals, especially for younger scientists --- was frustrated by the positive feedback loops inherent in the current funding structure. Funding success rates and career prospects did improve somewhat during the five years of rapid budget increases, but once the doubling had been completed proposal success rates quickly declined --- to levels even lower than before the budget doubling began. And the largest negative effects seem to have been concentrated among younger biomedical scientists, who represent the future of the research enterprise.[4]

What Should NOT Be Done?

The NIH case may not tell us what should be done now, but it does offer valuable insights into what should NOT be done. It also points to (again) foreseeable problems if the current structure remains unchanged and Congress carries through with the increased appropriations for NSF, Department of Energy and NIST foreshadowed in recent authorizations. I do hope this Committee will give some scrutiny to how repeats of the current rebound crisis from the NIH budget doubling can be avoided if the science funding budgets of these other agencies are doubled in the coming years.

What should NOT be done is to take actions that will increase the supply of scientists and engineers that are not intimately coupled with serious measures to ensure that comparable increases occur in the demand for scientists and engineers. A supply-side-only focus---various advocates are lobbying for sharply increased research funding, more incentives for science and engineering students, more temporary or permanent visas for scientists and engineers, etc.---might satisfy the demands of influential interest groups over the short term. But if the overall structure currently in place is not modified, one can reasonably anticipate that the positive feedback loops in the current system will produce destructive effects over the medium term ---deteriorating grant success rates, and declining interest in science and engineering studies and careers among domestic students.

Implications of R&D Globalization

What can we say about the implications of quite recent trends toward globalization of R&D activities by U.S.-based employers? The first thing is to acknowledge that we don't really know in any detail what is happening now, and certainly not what is going to happen over the next 5-

---

[4] An excellent presentation on the NIH situation, presented at Harvard University last February by Dr. Paula Stephan of Georgia State University can be found at:
http://nber15.nber.org/sewp/Early%20Careers%20for%20Biomedical%20Scientists.pdf

10 years. Only a decade ago, no one would have forecast the rapidity with which it has become feasible and financially attractive for U.S. firms to outsource their R&D activities to low-wage offshore settings such as India and China. The general assumption then was that low-skill, low-wage manufacturing could and would be offshored, but that high-value-added R&D functions would remain in the U.S.

Clearly such confidently-asserted assumptions have proven to be false. However, the data as to the actual magnitudes and growth of such offshoring are very limited indeed, and the information we do have lags well behind the rapid pace at which such change seems to be occurring.

It has long been the case that no one has been able to accurately forecast future labor market demand for highly-educated scientists and engineers more than a few years into the future --- as an outstanding National Academies report on the topic concluded forcefully in 2000.[5] Such forecasting efforts have become far more difficult as a result of the quite-recent movement toward offshoring of high-level R&D activities, led by many U.S.-based companies and consulting firms.

One result is that the risks and uncertainties of pursuing a STEM career in the U.S. are rising. If one combines the erratic paths and future uncertainties of R&D funding flows from the Federal government, the boom/bust cycles that characterize many important high-tech industries, the uncertainties of Federal visa legislation, and the apparent rising trend in offshore outsourcing of R&D, it is very hard indeed to offer useful advice about the future prospects for a STEM career to a student with strong abilities and real interest in math and science. Certainly we can offer no assurances that they will find a “durable and resilient career path” in such fields.

What Should Be Done?

One thing that could and should be done is to dramatically improve the “signals” about such careers that are publicly available to prospective students. In particular, doctoral programs in many U.S. universities provide far less information to prospective and entering students about the career experiences of their recent graduates than do the law schools and business schools on the very same campuses. This should certainly change; students need to be provided with far better if they are to have realistic expectations as they embark upon a course of graduate study and postdoc research that often can stretch out over most of their 20s.

A second promising approach is to improve the direct connections between science employers and universities offering graduate science degrees. This is one of the fundamental elements of the ***Professional Science Masters*** degree programs that the Sloan Foundation has

---

[5] National Research Council, Office of Scientific and Engineering Personnel, Forecasting Demand and Supply of Doctoral Scientists and Engineers: Report of a Workshop on Methodology (Washington: National Academies Press, 2000).

been supporting around the country. Typically these degrees involve two years of intensive graduate-level course work in relevant scientific fields, combined with courses in so-called "plus" skills that employers routinely report they seek in new hires: skills in communication, management, teamwork, leadership, entrepreneurship, along with on-the-job experience via internships with interested employers.

I am attaching to this testimony a one-page flyer that summarizes the Professional Science Masters. Much more information can be found easily at www.sciencemasters.com

I want to add in closing that it was personally encouraging to me that the Congress provided the first authorization of Federal funding in support of Professional Science Masters programs, via the National Science Foundation, as part of the America COMPETES Act passed a few months ago and signed into law. It will now be interesting to see if these authorized funds are appropriated, and if so whether the National Science Foundation will move energetically to build this promising graduate pathway toward strengthening the U.S. science workforce.

Thank you for your kind attention. I stand ready to answer any questions you may have to the best of my ability.