Summary of November 5-6 Roundtable Discussion

Note: This represents a summary of views expressed by individual roundtable participants at the meeting.

Summary of Student/Postdoc Panel
Dr. Sharon Hays, Deputy Director for Science, Office of Science and Technology Policy
Dr. Hays begins the meeting by providing background on these issues and the goals for the meeting. Several questions were outlined for consideration, including:

- Why are graduate students trained with a primary focus on becoming academics when fewer proceed along this career path (by choice or pure number of positions available)?
- Why does it take so long to earn a PhD and the length of post-doctoral fellowships continue to grow?
- Can we better predict supply and demand for scientists and engineers?
- How can we address challenges without undermining the science and engineering enterprise that is dependent upon graduate students and postdocs?

Panels Remarks

The panel provided the perspectives of two graduate students and two postdoctoral fellows. With differing perspectives and career paths, a number of interesting and informative themes developed:

- Undergraduate research or an early exposure to science (K-12) was generally important in developing their interest in a STEM field. Two individuals mentioned the NSF's Research Experience for Undergraduates program as having a critical role.
- Most panelists had not started graduate school directly after undergraduate studies. There were a range of interesting paths and experiences in-between these stages.
- Virtually all of the panelists pursued graduate studies because of their interest in research, but also because they believed it would give them control over their careers.
- All indicated that they received little career guidance along the way.
- Each panelist indicated a strong desire for information about industry and other non-academic career opportunities. This type of information and guidance was lacking and many believed it would have been critical early on in their education.
- Discipline-based societies/professional organizations and workshops provided a beneficial structure for career guidance.
- The majority of the panelists are planning to pursue non-academic careers- given the view that the personal (and professional) life of a professor is not desirable and some were discouraged by advisors.
- Panel appeared to have a grounded view of opportunities in academia- but there was a sense that many faculty still hold academic positions as the ideal career (first choice)
- Issues related to quality of life compared to other professions were raised.
- The role of mentors was critical and all wish they had access to information on diverse career opportunities earlier in their training/education.

Discussion Points

- Industry participants suggested importance of integrating business and management skills into training programs
- Research experience is critical and industry experience early in career can be very beneficial
    - Counter issue- if these opportunities are increased and there are more well qualified students for limited positions- if double size of programs students will be disappointed when no positions are present- how can career planning be accomplished in this system?
- This leads to a discussion of supply and demand- two opinions emerge-
    - Many participants mention issue of increasing supply but not closely examining the demand- this needs to also be viewed over long time periods as these are not rapid changes. System is over producing for positions that don't exist. If funding is increased, then this provides funding for increased workforce, but doesn't actually solve the supply and demand issue.
    - Counter opinion is that supply and demand is not the issue. Require increased Federal support for non-defense R&D- focused on basic research. This is the fundamental problem and will counter disruptions in the system.
- STEM professionals should likely plan for career transitions, having flexibility and diverse skills vs. planning to remain in a given field or sector for entire career.
- Challenges is 'work-life balance' versus other professions was also discussed.

Key points

- Early career planning is critical
- In general, there is a lack of guidance at institutions regarding career paths (foundations and societies provide some support)
- Providing a structure is essential to the training process- (provide clear expectations/requirements, develop interactions with private sector, government, career guidance, etc.)
- Mentors have a critical role and significant impact on students
- Early interest in STEM fields is formative
- Industry skills and metrics should be included as options in career development and training

Summary of Roundtable Discussion

Opening Remarks
Dr. John Marburger, Director, Office of Science and Technology Policy
Dr. Marburger opens with the importance of policymakers listening to the perspectives around the table. He mentions that Science should be communicative to the public, which, in turn, supports the complex science infrastructure. Deficiencies in that infrastructure affect the entire system. The U.S. Science sector is subject to various constraints, and is increasingly subject to competition from other countries, which are mimicking our approach, a phenomena which is discussed in *Rising above the Gathering Storm*. The least understood part of the fuzzy science infrastructure is the intersection of science and education. OSTP considers improving the understanding of the economic behaviors/drivers of graduate students and graduate programs in science and technology highly important, especially considering the diverse array of options that they pursue after graduation.

Introductions by Roundtable Participants

Trends in the System of STEM Graduate Education and Workforce Development
What can we learn from the data? — Panel & Discussion
Moderator- Dr. Daryl Chubin, Director, Center for Advancing Science and Engineering Capacity, American Association for the Advancement of Science
Dr. Chubin references the Graduate Panel from the previous night as the "face" of this discussion. He uses slides depicting the demographics of the STEM education population at various ages from childhood through early adulthood [see PowerPoint] to suggest approaches to changing STEM education. He emphasizes the importance of disaggregation to see trends by demographic group and academic discipline.

Dr. Cora Marrett, Assistant Director for Education and Human Resources, National Science Foundation
Dr. Marrett's presentation [see PowerPoint] focuses on emerging careers in STEM fields, based on trends seen in NSF data, as well as the policies and policy changes that the trends suggest.

Dr. Debra Stewart, President, Council of Graduate Schools
Dr. Stewart's presentation [see PowerPoint] looks at completion and attrition rates in STEM graduate programs, based on data collected from universities under a grant from Pfizer and the Ford Foundation.

Dr. Lisa Frehill, Executive Director, Commission on Professionals in Science and Technology
Dr. Frehill focuses on disaggregating the STEM umbrella to distill the economic value of higher degrees by discipline based on a NSF dataset, compiled from the National Center for Educational Statistics [see PowerPoint] and discipline-based societies.

Dr. Charlotte Kuh, Deputy Executive Director, Policy and Global Affairs Division, The National Academies
Dr. Kuh uses a thought experiment to discuss the economic incentives for individuals pursuing higher-level STEM education and "incentive compatibility" between academia and the market, and the possibility of disequilibria and over/undersupply of STEM graduates [see PowerPoint].

Q&A
It is proposed that Dr. Kuh's thought experiment should be reconsidered in the context of a growing economy, an implicit belief held by many. A more appropriate set of metrics (e.g. an index of overall health quality instead of number of new molecular entities in the pharmaceutical sector) could confirm this idea. The discussion shifts to another metric: whether researchers in postdoctoral positions are nominally/technically "employed". An additional comment suggests that better integrating information regarding a wide range of career opportunities into graduate programs (rather than simple preparation for future laboratory research).

In these cases, "The Devil is in the Disaggregation", which focuses on what STEM graduates do – move on to tenured faculty position, think tanks, etc. The constraints regarding employment, especially for tenured faculty positions, could discourage efficient utilization of STEM graduates.

The importance of industrial representation in the room is highlighted, since non-federal R&D far exceeds its federal counterpart. Federal R&D funds support basic research, which complements private R&D, which supports later stages of product development. Emphasis is placed on the importance of basic research funded by the federal government, especially considering that the private sector is unlikely to invest in basic research because it does not yield products and profits directly. The results of basic research are public; the government should focus on how to leverage these results for domestic benefit in an increasingly globalized economy.

Lag in data collection could directly contribute to the perception of incentive compatibility: data from several years in the past result in career projections that are not aligned with the most immediate industrial needs (metaphor: a sales lot full of SUVs when the public wants hybrids). A focus could be placed more directly on what employers need.

Universities should have an interest in maintaining better contacts with their alumni to keep track of what they do after graduation as a means for a better predictor for what their current graduate students will do. Better descriptors are necessary to adequately describe STEM graduates' career choices (and avoid the "other" category).

The bottom line is return-on-investment (ROI), for both federal and university research dollars. The federal government can help reframe the ROI model by undertaking financial responsibility for basic research in universities.

STEM Graduate Education and Postdoctoral Training: Is the Current Model Evolving to Meet National Needs and Properly Serving Students? — Panel & Discussion
Moderator- Dr. Peter Fiske, President and CEO, PAX Mixer, Inc.

Dr. Norka Ruiz Bravo, Deputy Director for Extramural Research, National Institutes of Health
Dr. Ruiz Bravo opens with the change in the NIH workforce as a result of funding changes and proceeds to discuss trends in, first, the relationship between citizen and non-citizen researchers and, second, the means of support for STEM graduate students [see PowerPoint].

Dr. Michael Teitelbaum, Vice President, Sloan Foundation
Dr. Teitelbaum focuses on the alleged mismatches between STEM graduate education and the needs of the nation with an emphasis on how the complex STEM education system can evolve to better meet those needs, concluding that STEM academic-workforce mismatches are not necessarily real dangers in the long-run provided the education system evolves with demand [see PowerPoint].

Dr. David Skorton, President, Cornell University
There is ample evidence to suggest that this is not a zero-sum game in the context of the American Enterprise. There is still particular promise in life and materials sciences. One-third of Cornell tenure-track faculty is expected to retire within 15 years; the graduate students of today will replace them.

There is not, nor has there ever been, enough money in the system. The US, ranking 22nd in non-defense basic research funding, lags behind too many other countries. Chuck Vest, in *Rising above the Gathering Storm*, predicts that the next Administration will have to address a new economy, based on knowledge. Examples from China and India reveal that the playing field is expanding at an increasing pace. Research funding must be placed back on the national agenda.

Evolution in STEM education is a result of, at least in part, students who realize they need additional skills, say, in business, etc. But, the doctoral degree is still too long and too costly and the postdoctoral experience is ill-defined across institutions. These students can add courses in other areas to add value to the degree. Another relatively new option is the professional master's degree, of which Cornell offers 14 in engineering disciplines. Non-STEM fields tend to field the professional degrees better by offering better career support and career advice from faculty. The NSF IGERT program is terrific and facilitates interdisciplinary learning. The "Business of Science and Technology" initiative at Cornell mixes Engineering PhDs with MBAs to complete company-sponsored projects. The more we look at STEM education at the national level (before the university level), the less we worry about small part of the system and focus on its smoother operation as a whole.

Public universities can learn lessons from the private sector. Moving discovery from the lab to a product affects the entire national economy, but not significantly enough at the university level. Annual royalties aggregated across all U.S. universities were only $1.2 billion.

The FBI National Security Advisory Board unites university presidents with representatives with National Security expertise from the Administration to discuss the balance between national security and academic freedom.

Discovery needs to be back on the national agenda.

Dr. Joann Eisenhart, Vice President, Human Resources, Pfizer, Inc
Dr. Eisenhart discussed the "shrinking" pharmaceutical workforce from the perspective of industry, including recruitment and retention of employees with unique talent, as well as the dynamics of the private sector research and development budget [see PowerPoint].

Dr. Peter Fiske, President and CEO, PAX Mixer, Inc.
Dr. Fiske, speaking with the voice of "Other"—someone who followed a non-traditional career path after graduation—reflected on the preceding discussion on demand-side constrains on the STEM workforce. He suggested that STEM graduates need to advertise their capacity for investigation and problem solving over their discipline-specific expertise.

Science has become locked into a big-industry mold, but job creation in the U.S. happens in small companies, where innovation and entrepreneurship are critical. Our capacity to convert great ideas into marketable ideas is uniquely American, and should be leveraged in universities, where it is conspicuously absent today. Programs like "Business of Science and Technology" at Cornell and the "Management of Technology" at UC-Berkeley can be catalytic for science-minded students by helping them open their eyes to their innovative potential.

Policy has not changed in the past 10 years, and is not necessarily likely to, but attitudes still can. Encouragement should not direct faculty to inject breadth into their fields – breadth is not their expertise. Rather, faculty should instruct students to do the best science they can.

Q&A
A large wave of faculty retirement is imminent because of combined demographics – either because of old age or because they can still do something else.

The research community will resist efforts to link research grants with training requirements, probably because 1) the principal investigator has more flexibility with research assistants (compared to fellowships and traineeships) and 2) RAs support both citizens and non-citizens, but fellowship and traineeships are restricted to citizens. Administrators have been hesitant to make significant changes without data to support their decisions, but such detailed data are not available. There is NIH data to use for reflection, but it is limited. It overlooks the need for demographic disaggregation to examine underrepresented groups.

There is not a shortage of PhDs hoping to work in the private sector. Dr. Eisenhart's figure of 125 new PhD hires annually, is not a large figure relative to the number of people graduating with degrees in biomedical fields. In response, Dr. Eisenhart raised the issue of quality – the PhD or a postdoctoral experience in and of itself does not qualify a candidate for employment.

Many important tools (complex modeling, etc.) in industry were developed entirely within academia, but neither academia nor industry are making significant efforts to develop technology transfer programs to bridge the transition between the two. The programs that do exist are completely separate from university institutions (SBIR) or controversial (ATP).

From an industry perspective, government research programs are distant and do not have visible impacts on a regular basis. Additional comments pointed out that the funding for R&D as a percent of total expenditure has remained constant, while the number of projects has increased, which can be interpreted as more investment at less cost/greater efficiency.

But, technology transfer happens not only through patenting and commercialization, but also through the recruitment and employment of graduate students previously involved in related university-level research. Not all students go directly to industry. For example, AAAS runs programs that put students in other settings to help them to see problems from different view points and subsequently facilitate communication across sectors.

Comments focus on the differences among employment in STEM disciplines. While computer sciences and mechanical engineering enjoy full employment, the biological sciences face a very different story. Aggregating these different systems into one "STEM" analysis can be problematic. Also, researchers must be mindful that research results can take decades.

There are lessons learned from getting money back to the student. DOD has a service-payback program for fellowships that has been tremendously successful, as evidenced by hard data. This differs from the NIH program, which did not explicitly consider the impact of an increase in the number of researchers before doubling their budget. NIH appears to fund the research while DOD funds the person/investigator.

Idea for the need of a "structural change" and current cultural divide between universities and industry. The university, as a supplier, should be more permeable to the kinds of work opportunities that graduates will face. These changes could take the form of new degrees, internships, career information on campus, faculty retooling (professional development for PhDs), and industry representatives on campus for technical assistance.

Results of Breakout Discussions

<u>Issues raised by individuals in the Government breakout group:</u>

- Data
    - These are long trends; they do not change quickly and require appropriate interpretation
    - For meaningful data, require a few good indicators (including questions about career choices) collected in a timely way
    - Data need to be more disaggregated to be more meaningful
    - Longitudinal tracking (e.g. of students/postdocs after completion/leaving program, and retrospectives on experience) is the only way to get a complete picture

  - Government level data can be more timely, and institutions need to be looking at their data more quickly (exit interviews, etc.)

- Broadening the training experience – externships, presence on campus
  - Issue "Grand Challenges" and help focus priorities
  - Need to create more flexible ways to bring students into government and industry laboratories (esp. in science/security areas) - current slots are few and even a few weeks would be worthwhile experience. There is no mechanism for arranging short visits. Need mentors and training to support.
  - Scientists can be helpful to the government as international ambassadors "Scientists Without Borders" and could travel accordingly within training programs.
  - Identify broad areas of science that are multidisciplinary and cross agencies, (e.g. energy, nanotechnology, health/medicine, climate change, etc.) and create special training opportunities for those areas.
  - Begin clearance processes earlier in students' careers so that if they choose that path, the clearance process can happen in a timely fashion.

- Innovation – valley of death and bridging funding between basic and applied science
  - Broaden SBIR programs or ATP /TIP. Open up SBIR programs so that ideas come from the private sector and are not driven exclusively by focused agencies needs.
  - ATP/TIP as a mechanism to connect academic/fundamental research to the marketplace. ATP (Advanced Technology Program) program (NIST) targeted high-risk, high-payoff research; TIP (Technology Innovation Program) is re-scoped to address fundamental research.
  - Increased cooperation among science, engineering, and business schools, which is often a grassroots effort.

- Diversity
  - Need to further enforce existing programs
  - Consider tax credits for minority training that can be incorporated into research tax credit programs
  - US is behind other countries in making family care allowances for women in the sciences – opportunity to create better programs here

- What should the government be doing less of?
  - Balance funding and reporting requirements: less requirements for data that is not informative for evaluations and policy
  - Vague restrictions/requirements related to security classification and ITAR issues

<u>Issues raised by individuals in the Academia breakout group:</u>

- Make barriers more permeable or build better bridges
  - Skill sets (transferable skills—those not at core of discipline)
  - Interdisciplinarity
  - Interaction among stake-holders: between students and employers

- Develop systems that foster mutual respect between the academy and industry to facilitate students pursuing industrial careers
  - eg. Internships, industrial appointments on faculty

- Examine internal graduate education processes and practices to ensure student success
    - completion rates
    - time to degree
    - mentoring

- Emphasize transferable skills and develop a more grounded understanding to identify those skills

- Sustain a place in graduate education to foster innovation and entrepreneurship for some portion of the graduates

<u>Issues raised by individuals in the Industry breakout group:</u>

What does Industry want?

- Global competency
- Multi-disciplinary problems without a clear/single solution
- Ability to work in teams
- Professors with industry experience
- Professional integrity
- Communication

How to achieve?

- Collaborative programs between University and Industry
    - BS through PhD/Postdoc
- Embedded researchers (eg. Sabbaticals at all levels)
- IGERT (Integrative Graduate Education and Research Traineeship) and PSM (Professional Science Masters) as models
    - Needs rebranding
- Double-headed arrow: flows back and forth between Industry and University sectors

Contrarian view-

- Critical top increase Federal basic research funding.
- Use America COMPETES Act and ACI as guides

Discussion
University faculty can enhance their relationship with graduate students. Faculty advisors are important media through which future opportunities for graduate students under their tutelage are communicated. The faculty can work to enhance the information they pass along to help students better project their career paths. A more tightly knit community – even across fields – will be useful for students to gain a broad view of the economy, especially since boom-bust cycles can plague very specialized fields. Talking across groups not only facilitates this broad view, but will also enable more general conclusions about the appropriate approach to graduate education. Professional societies can play a key role in conducting this dialogue, especially considering that many faculty feel more closely tied to their profession than their campus.

In general, academics train students to become academics, because that's what they know how to do. In many cases, industry can take individuals with specialized academic training as long as they have a broad skill set to be crafted into what industry needs. The "Others" seem to fit into three categories, all of benefit from STEM-literacy: journalism, civil service, and the legal profession.

Ph.D. programs seem to take longer than necessary, especially in comparison to MD-PhD programs, which require approximately the same amount of time for twice the certification. Ultimately, the length of time is field-dependent, and should be quantified as total time actually enrolled, instead of time between enrollment and graduation, since many students are involved in other programs or take time off. Admittedly, some students elect to stay in a doctoral program longer than necessary because it is familiar and guaranteed, which seems to offer a bright future in contrast to the dark abyss of the uncertain job market.

Community college needs additional consideration. Further efforts should also be directed at describing where those students who do not follow traditional paths after graduate programs. Further analyses should be directed at determining if the system of higher education produces the students we need or the students we think we should have.

Concluding Remarks
Dr. Sharon Hays
Dr. Hays extends her thanks to the participants and outlines several concluding observations. Many trends have not changed significantly in the past ten years. There are several important differences. The panel of graduate students embodied the various non-traditional paths now available to students, as well as a higher degree of realism about postgraduate opportunities, as opposed to pessimism and bitter feelings that were present ten years ago in some fields.

We have made important steps in collecting more data. The doubling of the NIH budget has been a natural experiment – we need to continue to mine this data to extract the appropriate lessons, especially since we are in the process of doubling the budget of three other agencies. We need to examine changes to the system over time, considering its complexity and inertia.

Graduate STEM education is rarely a priority for those outside the community (such as congressmen and policymakers). It is the responsibility of those involved in this conference to raise awareness in the public eye.