FUTURE OF BIOSCIENCE GRADUATE AND POSTDOCTORAL TRAINING

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FUTURE OF BIOSCIENCE GRADUATE AND POSTDOCTORAL TRAINING

This report summarizes the outcomes of the first and second national conference on the *Future of Bioscience Graduate and Postdoctoral Training* (FOBGAPT 1&2). These conferences were convened to discuss the major challenges facing education and training in the biosciences and develop national consensus and make policy recommendations around five key topics that can be adopted by academic and research institutions and federal funding agencies (see Hitchcock et al., 2017). Each conference was organized around concurrent workshops that were chaired by a small group of experts that guided the topic under discussion. Included in this report are links to videos of the plenary lectures that opened the two conferences, 'What Works' abstracts submitted by conference participants, and relevant published articles.

We invite readers to join the discussion on Twitter at: #FOBGAPT.

INTRODUCTION

For over two decades there has been ongoing discussion of the changing nature of careers for bioscientists - whether we are training too many Ph.D.s, whether we are preparing our students adequately for future careers and the glaring lack of diversity in the scientific workforce. Discussions have intensified in the last few years, with seminal publications calling for change (NIH Workforce Report, 2012; National Academies Report, 2014; Alberts et al., 2014; Daniels, 2014; Gibbs et al., 2014; Gibbs and Marsteller, 2016) and local, regional and national conferences convened to advance the conversations and identify tractable solutions (McDowell et al., 2014; Kimble et al., 2015). In 2015, the University of Michigan hosted a national meeting, FOBGAPT1, with representatives from research universities, medical schools, foundation and federal funding agencies, the private employment sector and pre- and post-doctoral trainees. The goal of this conference was to discuss the many proposals that had been published and debated and to serve as the starting point for a second national conference to develop national consensus and national policy recommendations. A second meeting, FOBGAPT2, was held in June 2017, jointly hosted by the University of Colorado Denver|Anschutz Medical Campus and the University of Michigan Rackham Graduate School. For each conference, topics were identified by an organizing committee* in advance of the meeting as those most in need of further institutional and/or national policy solutions.

FOBGAPT 1
May 2015, University of Michigan

Workshop Chairs

Jabbar Bennett, Northwestern University; David Cardozo, Harvard University; Roger Chalkley, Vanderbilt University; Andrew Feig, Wayn State University; Kenneth Gibbs, National Cancer Institute; Jerome Kukor, Rutgers University; Edith Lord, University of Rochester; Gary McDowell, Future of Research.org.; Mary O'Riordan, University of Michigan; John Russell, Washington University; Nancy Schwartz, University of Chicago; Nancy Street, University of Texas Southwestern Medical Center; Michele Swanson, University of Michigan; Victor DiRita, University of Michigan; Jonathan Wiest, National Cancer Institute.

Video: FOBGAPT 1 Plenary Lectures

Seven concurrent workshops were held in FOBGAPT1: *Experiential learning outside the university; New models for training bioscientists; Curricular reforms; Career track options; How to correct gender and diversity imbalances; Funding models; How to assess and balance Ph.D. supply and demand, now and into the future.*

The FOBGAPT1 conference brought together education leaders from different institutions and sectors across the country to discuss major challenges in graduate and postdoctoral education. Although the composition and distribution of the biomedical sciences workforce has changed dramatically over the last twenty years, key studies revealed that biomedical sciences training had not evolved consistently or by consensus to reflect the evolving needs of our trainees. A common thread reflected across

conference discussions emphasized that the classic apprenticeship model of scientific training remained central to producing outstanding scientists, but was no longer sufficient to prepare trainees for the varied career opportunities now available within and beyond academia. The workshops revolved around two major themes: (1) new curricular and extracurricular models of training, and how such models might address persistent gender and diversity imbalances, and (2) funding structures for supporting enhanced training and additional career tracks within the academic sector.

Concepts for modernizing biomedical sciences training centered on new aspects of scientific innovation and professional skill development. Guiding principles for curricular reform were that research and critical thinking should remain as a fundamental platform for doctoral education, but training should be expanded to integrate scientific, quantitative and professional skills training. Moving away from didactic teaching towards modular competency-based learning would provide a more agile and interdisciplinary approach. Experiential learning in science-related environments was proposed as a valuable component to enhance curricular training, and expose trainees to a breadth of available career opportunities. Participants acknowledged the need for a portfolio of solutions that spanned a continuum of resources and trainee time commitment, ranging from short 1-3 day exposures to months-long externship projects. Models for a richer overall training and mentoring experience were a topic for robust discussion. While mentorship and professional development have traditionally relied on individual research mentors, there was a strong consensus that the traditional approach resulted in inconsistent training experiences across programs and institutions. To address these gaps, mechanisms were proposed to align expectations between institutions, mentors and trainees, including expansion and integration of professional development within the curriculum, creating infrastructure for broad training oversight and outcomes tracking, and establishment of clear expectations and rubrics for faculty mentoring. In addition to variable training experiences, the current paradigm lacks sufficient incentives to promote diversity and inclusion, and has led to a disconnect between diversity and perceived excellence. Here too, infrastructure to better track outcomes and broadly educate the scholarly community on mentoring and unconscious bias was considered as important for supporting a more diverse and inclusive culture. Development of strategic plans for diversity and inclusion, coupled with accountability at the institutional and federal level, would be a strong step towards righting current imbalances. The emergent themes that cut across these workshops were the urgent need for innovation and culture change in biomedical sciences training, and for better mechanisms for disseminating best practices across laboratories, departments and institutions.

A strong driver for the need to shift the training paradigm has been the rapid expansion of the trainee population upon doubling of NIH research funding in the 1990s, followed subsequently by flat or declining budgets. The imbalance created by this rapid expansion led to the question of how to assess and govern supply and demand for PhD scientists. The de-centralized nature of academic training at institutions across the country and the current deficit of standardized data collection for outcomes tracking were identified as major challenges to understanding the supply problem. With no single recognized national governance body for graduate education, proposed solutions to the supply problem focused on better data governance, proactive education of prospective and current trainees on career outcomes and deeper exploration for whether the prospect of a fully paid PhD education disproportionately motivates students to enter the scientific pipeline. This discussion also underscored the need for expanding the professional skill set for trainees to create a pool that meets the diverse demands of today's biomedical sciences workforce. Notably, engaging a variety of academic and non-academic stakeholders in the biomedical sciences community as advisors was put forward as a way to better align supply and training with the demands of the workforce. There was a sense that current research funding mechanisms had dis-incentivized innovation in training, and that defining the appropriate balance for federal support of training vs. research mechanisms might naturally constrain entry of trainees into the education system. Without such constraint, re-imagining the current academic workforce structure to create more mid-

level career opportunities, such as research specialists or staff scientists, was considered an important avenue to stabilize the training pipeline. The cost of such experienced scientists in the context of limited research dollars presents a major barrier to shifting the academic research paradigm to include more career research positions. Taken together, these discussions revealed the difficulties in changing what has evolved as the fundamental structure of academic science, but clearly pointed to a need for experimenting with new mechanisms of funding scientific research and training to more productively re-structure the scientific enterprise.

FOBGAPT 2
June 2017, University of Colorado Denver, Anschutz Medical Campus

Workshop Chairs

Jabbar Bennett, Northwestern University; Patricia Cameron, Augusta University; Christine Chow, Wayne State University; Philip Clifford, University of Illinois Chicago; Robert Duvoisin, Oregon Health and Science University; Andrew Feig, Wayne State University; Kevin Finneran, National Academy of Sciences; Diane Klotz, Sanford Burnham Presbyterian Medical Discovery Institute; Ambika Mathur, Wayne State University; Richard McGee, Northwestern University; Mary O'Riordan, University of Michigan; Christine Pfund1, University of Wisconsin-Madison; Christopher Pickett, Rescuing Biomedical Research, AAAS; Nancy Schwartz, University of Chicago; Nancy Street, University of Texas Southwestern Medical Center; Elizabeth Watkins, University of California San Francisco; Jonathan Wiest, National Cancer Institute.

Video: FOBGAPT 2 Plenary Lectures

Five concurrent workshops were held during FOBGAPT2: *How better to increase the diversity of scientists in senior and leadership roles; How to increase engagement and skills of faculty in mentorship; How to modernize (and keep updating) curricula and training while maintaining the basic tenets of research and scholarship; How to increase the engagement of the private sector and other potential employers in bioscience training; How to collect national-level data on Master's and PhD students and postdocs and use these data to inform trainees and training.*

The current stresses on federal funding and the mismatch between supply and demand have been addressed previously (e.g., Alberts et al., 2014; Levitt and Levitt, 2017; see above) and were expressly excluded from these discussions. Each workshop, facilitated by recognized experts, was repeated five times over the course of two days at the end. Each workshop then concluded with a final culminating session to refine their recommendations. Attendees included university administrators and faculty, funding agency representatives, journal editors, postdoctoral fellows, and graduate students. Each attendee was encouraged to participate in multiple workshops, which promoted a thorough discussion of each topic and contributed to developing consensus on recommendations. In addition, attendees were encouraged to submit 'What Works' abstracts that describe effective practices at their respective institutions. The abstracts were accessible to session facilitators and attendees in advance of the conference and can be found on the conference web site.

Each successive iteration of the workshops served to identify the issues underlying the topic at hand, focus the conversation on tractable solutions and develop specific recommendations that can be implemented (Table 1). Below, we provide an introduction to each workshop and the recommendations that emerged from the discussions.

Workshop 1: *How Better to Increase the Diversity of Scientists in Senior and Leadership Roles*.

The paucity of members of underrepresented groups in senior and leadership positions in the biosciences is not a new phenomenon. Diversifying within these roles and charting a pathway toward them for women and underrepresented minorities is essential, but remains a challenge. The postdoctoral research appointment is a key moment in the training of an underrepresented scientist, and training experiences during this important transition point have the greatest potential to positively or negatively impact career trajectory and success.

Postdoctoral training alone does not determine future course or success. Factors that impact a pathway toward successful leadership roles include awareness of and access to various career development resources, including mentors, and the presence of peers with similar experiences. Barriers to success include a lack of clear review criteria and implicit biases that impact hiring, funding grant applications, peer review of publications, and recognition and awards. All too often, these challenges follow underrepresented scientists as they progress in their careers. Therefore, academic institutions, corporations, governmental and scientific organizations, funding agencies, publishers, and professional societies have important roles to play in diversifying senior and leadership positions. Assessing climate and culture and promoting the development of underrepresented scientists must be done intentionally and requires full support of institutional leaders.

Recommendations

1. *Begin leadership training early, focusing on graduate students and postdoctoral fellows*

   It is crucial to invest early in the professional development and leadership training of underrepresented graduate students and postdoctoral fellows. This will help ensure their overall success, as well as the success of employing institutions and organizations. Graduate students and postdocs must be exposed to the variety of career paths and encouraged to develop and communicate their professional career goals with faculty and senior leaders. Simultaneously, the power dynamics between these trainees and their advisors must be acknowledged, along with the role that social identities may play during these interactions.Addressing these issues along with other relevant core competencies and skills will assist in promoting the success of these future leaders.

2. *Provide incentives and awards for programs that impact institutional culture which enhances diversity, equity, and inclusion*

   Incentives and awards help create and sustain a more inclusive culture and climate. Outcomes, measureable goals, and systems for accountability must be established and connected to the institutional vision, mission and values. Institutions may consider tying accountability metrics and performance to compensation and promotion. Leaders must underscore the importance of this work and how an inclusive culture is essential for the success of the institution. It will be important to provide education and training to every member of the institution around these priorities.

3. *Change review practices for recruitment, hiring, promotion, funding, publications, and awards*

   These changes will enhance diversity and promote inclusive excellence. Implementing blind review and selection processes and revamping fellowship and grant review panels and study sections should be explored. Require all reviewers to complete implicit bias training is strongly encouraged. Once changes have been made, it is important to analyze outcomes and utilize these data and results to inform others and encourage broader change.

4. *Require inclusivity training for all senior administrators, faculty, staff, postdocs and graduate students*

   Such training will help ensure that everyone acknowledges, understands and appreciates the value of diversity. Provide data and use metrics to support and emphasize the need and importance of these enrichment activities. Avoid framing this as mandatory training, as it may offend individuals who don't perceive themselves to have deficits in this area. A better strategy may be to focus on specific topics and the need to be in compliance with local and federal guidelines and expectations.

5. *Establish major funding mechanisms to prepare underrepresented postdoctoral fellows for transitions into successful careers*

   Expanding such funding mechanisms is paramount to increasing the number of leaders from underrepresented groups. It is important to expose and prepare postdoctoral fellows for leadership positions and careers both within and outside the academy. For those trainees seeking

career paths outside of the academy, mentoring, training options and funding resources must exist that will allow fellows to move beyond their current roles. Cross-institutional approaches will be important to share best practices and increase awareness of career opportunities.

Workshop 1: *What Works* Abstracts

Guerrero-Medin G, Feliú-Mójer M. Yale Ciencia Academy: Leveraging a Hispanic Science Network to Enhance Graduate Biomedical Training, Career Success, and Diversity, Yale University, Provost Office, Yale Ciencia Initiative, University of California, San Francisco, iBiology and Ciencia Puerto Rico.

Olivero OA, Sutton S, Wiest JS. The NCI-Diversity Career Development Program (NCI-DCDP). A Successful Intervention to Identify Unique Talents. National Cancer Institute, National Institutes of Health, Life Solutions, Boston, MA.

Workshop 1: Published Resources

Barfield WL, Plank-Bazinet JL, Austin Clayton J. Advancement of Women in the Biomedical Workforce: Insights for Success. 2016, Academic Medicine, vol. 91(8).

Coalition of Urban Serving Universities, Increasing Diversity in the Biomedical Research Workforce. American Association of Medical Colleges, 2016.

Elsevier. Gender in the Global Research Landscape. 2017.

Gibbs KD, McGready J, Griffin K. Career Development among American Biomedical Postdocs. CBE-Life Sci. 2015, vol. 14.

Ginther DK, Schaffer WT, Schnell J, Masimore B, Liu F, Haak LL, Kington R. Race, Ethnicity, and NIH Research Awards. Science. 2011, 333:1015-1019.

Ginther DK, Kahn S, Schaffer WT. Gender, Race/Ethnicity, and National Institutes of Health R01 Research Awards: Is There Evidence of a Double Bind for Women of Color? Acad Med. 2016, vol. 91(8).

McGee R. Biomedical Workforce Diversity: The Context for Mentoring to Develop Talents and Foster Success Within the 'Pipeline'. AIDS Behav. 2016, DOI 10.1007/s10461-016-1486-7.

National Research Council. Gender Differences at Critical Transitions in the Careers of Science, Engineering and Mathematics Faculty. 2010, National Academies Press, Washington, DC.

National Academy of Sciences. Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads. 2011, National Academies Press, Washington, DC.

National Institutes of Health. Draft Report of the Advisory Committee to the Director Working Group on Diversity in the Biomedical Research Workforce. 2012.

National Science Foundation. National Women, Minorities, and Persons with Disabilities in Science and Engineering. 2017.

Plank-Bazinet JL, Bunker Whittington K, Cassidy SKB, Filart R, Cornelison TL, Bett L, Austin Clayton J. Programmatic Efforts at the National Institutes of Health to Promote and Support the Careers of Women in Biomedical Science. Acad Med. Vol 91(8).

Valantine HA Collins FS. National Institutes of Health addresses the science of diversity. Proc Natl Acad Sci. 2015, 112: 12240–12242.

Workshop 2: *How to Increase the Engagement and Skills of Trainees and Faculty in Mentorship.*

Growing literature supports the importance of mentoring and mentoring relationships on trainee satisfaction, productivity and persistence (Pfund et al, 2016; McGee, 2016; NAS, 2017). In the past decade, approaches and resources for improving mentoring relationships through mentor and mentee training have expanded. Yet, a higher level of engagement of mentors (and their trainees) with these activities and resources is still needed. A focus on increased engagement in mentoring will: (1) advance the skills of faculty in mentorship, building upon existing research and evidence-based approaches; (2) address the challenges and benefits of diversity in the biomedical training workforce; (3) encourage

implementation of improvements in mentoring across a range of institutions varying in their culture around training and mentoring; (4) enhance assessment of effectiveness and impact. The approaches employed should be sufficiently ambitious, yet feasible.
Future efforts to teach the elements and skills of effective mentoring should give more attention to trainees' self-awareness and self-actualization. A key goal will be to assist both mentors and mentees with finding perspective in a potential situation and knowing when to address it. Further, the context of the mentoring relationship is always changing, so there is a need for constant revision and communication. Also, there is a need for federal funding agencies to advocate for accountability for effective mentoring and consistent messages to all stakeholders. Finally, the need for easy access to central repositories of resources to guide skill-building in effective mentoring relationships is essential to continual improvement.

Recommendations

1. *Train mentors*
   Efforts should focus on building relationships, capacity for improvement, and activities and resources available to optimize relationships. It is important to include personality assessment, recognizing the cultural context for mentoring relationships and the need for culturally aware mentorship (e.g. NRMN; www.nrmnet.net). An effective approach should include senior faculty as facilitators, as a means to promote their engagement. Engaging graduate students and postdoctoral fellows in mentor training will empower them to guide their own mentor relationships. Traditional mentorship training for research mentors should be complemented with skill building that will allow mentors also to provide career coaching.

2. *Train mentees*
   The quality of mentoring relationships is a shared responsibility with both mentors and mentees. Both groups need skills to navigate their relationships successfully. This includes effectively navigating power dynamics. The best approach to gaining these skills is an iterative process across career stages, with varied design and dosage at each step of the mentee's stage (termed 'Mentoring Up' (Lee et al 2016). Inclusion of mentee self-assessment is especially critical for transitioning in later phases.

3. *More effectively market the value of training*
   Effective arguments and messages to encourage mentor training should focus on how effective mentoring increases the productivity of the research group. Published data, including those from a randomized controlled trial (Pfund et al., 2015), show training outcomes include mentor satisfaction with training, gains in the mentors' knowledge, changes in the mentors' behavior, and mentees noticing the changes in mentors. Additionally, training can minimize mentoring conflicts, thus saving time, energy, and resources. Moreover, building a reputation as an effective mentor improves recruitment of students and postdocs. Language matters when advertising mentor training. Workshop titles like "Increasing the productivity of your lab" and "Optimizing mentoring relationships" are effective. It is best to avoid using the word 'training' or 'mandatory'. The origin of messages also matters. Top-down mandated training can easily backfire and result in unintended consequences. Having faculty peers select and personally invite participants, saying "we need more folks at your experience level," can be important. Department chairs and other leadership can be very impactful in recruiting mentors to participate. Do not overestimate faculty resistance to training opportunities; there may not be as much as expected.

4. *Encourage trainees to seek multiple mentors and build mentoring networks*
   Moving from the classic dyad to mentoring networks or mosaics will help trainees receive the effective mentoring they need. Including formal and informal mentors, peer mentors, career mentors or coaches, singly or in groups and across fields beyond academia, provides an opportunity to build both structured and unstructured mentoring networks. Enabling and promoting mentoring networks should also be a role for scientific societies and national initiatives (e.g., NRMN). Building mentoring networks should

start with self-assessment through an IDP, where mentoring needs are identified and outreach to mentors starts. A 'mentoring map' is a great tool to make mentoring visible and real.

Workshop 2: *What Works* Abstracts

Hutto T, Atlanta BEST Program. Maximizing Mentorship: Faculty and Trainee Fall Workshop Series, Emory University and Georgia Institute of Technology.

Loughlin SE, Coutin S, Leslie FM. Training Future Faculty in Mentoring, University of California Irvine.

Moorhead D. Empowering Students Enhances Faculty Mentorship, University of Toledo.

Rackham Graduate School. Mentoring Others Results in Excellence, University of Michigan.

VanAndel Research Institute. VAIGS Mini-Report: Core Competencies for Student Assessment and Program Effectiveness. 2017.

Vincent M, Fontaine A, Wefes I. PACT: Postgraduate Advisors for Career Trainees, University of Colorado Denver|Anshutz Medical Campus.

Workshop 2: Published Resources

Bakken LL, Byars-Winston A, Bundermann DM, Ward, EC, Stallery A, King A, Scott D, Taylor RE. Effects of an educational intervention on female biomedical scientists' research self-efficacy. Adv in Health Sci Educ. 2010, 15:167-183.

Byars-Winston A, Guiterrez B, Topp S, Carnes M. Integrating Theory and Practice to Increase Scientific Workforce Diversity: A Framework for Career Development in Graduate Research Training. CBE—Life Sci Educ. 2011, 10:357-367.

Turner de Tormes Eby L, Allen TD, Hoffman BJ, Baranik LE, Sauer JB, Baldwin S, Morrison MA, Kinkade KM, Maher CP, Curtis S, Evans SC. An Interdisciplinary Meta-Analysis of the Potential Antecedents, Correlates, and Consequences of Protégé Perceptions of Mentoring. Psychol Bulletin. 2016, Advance online publication. doi:10.1037/a0029279.

De Welde, K, Laursen SL. The "Ideal Type" Advisor: How Advisors Help STEM Graduate Students Find Their 'Scientific Feet'. Open Educ J. 2008, 1:49-61.

Gibbs KD, McGready J, Griffin J. Career Development among American Biomedical Postdocs. CBE-Life Sci. 2015, 14.

Lunsford LG, Baker VL. Great Mentoring in Graduate School: A Quick Start Guide for Protégés. Council of Graduate Schools, Occasional Paper Series. 2016, 4.

McGee R. Biomedical Workforce Diversity: The Context for Mentoring to Develop Talents and Foster Success Within the 'Pipeline'. AIDS Behav. 2016, DOI 10.1007/s10461-016-1486-7.

Pfund C, Maidl Pribbenow C, Branchaw J, Miller Lauffer S, Handelsman J. The Merits of Training Mentors. Science. 2006, 311:473-474.

Pfund C, House SC, Asquith P, Fleming MF, Buhr KA, Burnham EL, Eichenberger Gilmore JM, Huskins WC, McGee R, Schurr K, Shapiro ED, Spencer KC, Sorkness CA. Training Mentors of Clinical and Translational Research Scholars: A Randomized Controlled Trial. Acad Med. 2014, 89:774-782.

Pfund C, Spencer KC, Asquith P, House SC, Miller S, Sorkness CA. Building National Capacity for Research Mentor Training: An Evidence-Based Approach to Training the Trainers. CBE—Life Sci Educ. 2015, 14.

Pfund, C, Byars-Winston A, Branchaw J, Hurtado S, Eagan K. Defining Attributes and Metrics of Effective Research Mentoring Relationships. AIDS Behav. 2016, 20:S238-S248.

Rose GL. Group Differences in Graduate Students' Concepts of the Ideal Mentor. Res in Higher Ed. 2005, 46:53-80.

Sauermann H, Roach M. Science PhD Career Preferences: Levels, Changes, and Advisor Encouragement. PLoS ONE. 2012, 7(5).

Sorkness CA, Pfund C, Asquith P, Drenzner MK. Research Mentor Training: Initiatives of the University of Wisconsin Institute for Clinical and Translational Research. CTS Journal. 2013, 6:256-258.

Stamp N, Tan-Wilson A, Silva A. Preparing Graduate Students and Undergraduates for Interdisciplinary Research. BioSci. 2015, 65:431-439.

Workshop 3: *How to Modernize (and Keep Updating) Curricula and Training While Maintaining the Tenets of Research and Scholarship.*

The diverse landscape of biomedical sciences is driving the need for curriculum change. Graduate and postdoctoral researchers use their scientific training to make important contributions in academia, industry, government, health, communication, philanthropy, nonprofits, and outreach. These highly diverse modes of scholarship and employment require a broad array of skills, abilities and knowledge, but our training paradigms are still largely aimed at producing academic researchers.

The gap between current training objectives and key competencies required to prepare trainees for success in today's biomedical workforce highlights an opportunity and need for transforming graduate education and postdoctoral training. Modernizing the graduate curriculum should align learning objectives with the wider spectrum of proficiencies valued in today's workforce. A broad framework should be utilized to engage the scholarly community in a stepwise process that will intentionally and iteratively modernize curriculum and training programs.

Recommendations

1. *Identify and refine key concept inventories and competencies (skills, abilities and knowledge).*
   Use core competencies identified by other groups and organizations (e.g. NIGMS Report, 2011; or National Postdoctoral Association Core Competencies) as starting points for institutional conversations. Key professional competencies can include skills in leadership, communication, management, teamwork and critical thinking. Emphasize establishing a foundation of broad and deep discipline-specific knowledge, computational skills, ethics, rigorous experimental design and reproducibility.

2. *Define desired outcomes.*
   Defined outcomes provide a critical framework for rubrics to assess progress at multiple stages throughout training, and create opportunities for valuable, constructive feedback on strengths/achievements, and areas for improvement and growth.

3. *Determine effective learning strategies.*
   While traditional didactic methods are still common, advanced learners may benefit from more learner-driven pedagogy. The "flipped classroom" is one example, though many additional modalities have been identified (e.g., bootcamps, workshops, nano-courses, online modules, experiential learning) that institutions utilize effectively in their portfolio of learning strategies. Training programs should design innovative methods to integrate professional skills training (e.g., communication, writing, teamwork) into pre-existing curricula. This will avoid increasing time to degree or diluting focus on research and scholarship.

4. *Map learning to the full training continuum.*
   Current graduate curricula are often front-loaded, condensing most formal learning into the first year or two of doctoral training. The period of scientific training spans a continuum, from the first year of graduate education through the last year of postdoctoral research. Throughout this continuum, educational and training opportunities for the full range of competencies should be intentionally designed to introduce, reinforce and confer mastery of competencies. "Just-in-time" learning, should integrate scientific concepts, advanced techniques and professional skills into a learning framework designed around a trainee's experience and maturation.

5. *Address barriers to curriculum change.*
   There is a major gap between what we as scientists and educators value, compared with our established practices. The most common barriers to change are a lack of faculty time, lack of incentives and resources, difficulty in coming to consensus, inertia in the academic culture and decentralized training structures. Successfully

modernizing the curriculum must have strong support from institutional leadership.

6. *Integrate regular assessment of trainees, trainers and program effectiveness.*
   There is a need for integrated program, trainer and trainee assessment to measure and support effective learning. There can be a striking discordance between the concepts and skills that faculty perceive they are teaching and what trainees perceive they are being taught and learning effectively. Moreover, training provided by individual faculty mentors in scientific and professional skills varies widely. Thus, regular learning assessments to support evidence-based educational approaches are critical to ensure that programs effectively provide trainees with strong knowledge foundations and professional competencies.

7. *Bring the discussion of competencies to stakeholders at the institutional/program level.*
   Engage faculty, trainees, alumni, professional societies and employers in evaluating strengths and gaps in current programs. Create a culture of transparent learning assessment, evaluation and effective communication that aligns the expectations of faculty and trainees for teaching and learning.

8. E*stablish a national repository to disseminate and share relevant resources and best practices.*
   One example of such a resource is provided by the American Society for Biochemistry & Molecular Biology (Fuhrmann, 2016) is one example.

Workshop 3: *What Works* Abstracts

Al-Ani A, Zabinyakov N, and Rancourt D. Introducing Informational Interviewing into the Curriculum. University of Calgary.

Barral JM, Niesel DW, and Fowler GA. An Interactive Competency Approach to Career Exploration and IDP Implementation. University of Texas Medical Branch and American Psychological Association.

Behrman S, Schnoes A, Griffin N, McQuillen D, Feliú-Mójer M, Kirschner E, Goodwin S, and Vale R. Ibiology Ipert Courses for Graduate & Postdoctoral Training. University of California San Francisco and Ciencia Puerto Rico.

Fuhrmann CN, Thompson MN, Hall S, Lane ME, Imbalzano AN, Zamore PD, Carruthers A. An Integrated Curriculum and Community-Based Approach to Career Development. University of Massachusetts Medical School.

Kahn RA, Conn GL, Corbett AH. Use of a Grant Writing Class in Training PhD Students. Emory University School of Medicine and Laney Graduate School.

Lane ME, Moore M, Baker R, Munson M, Tissenbaum H, Silverman N, Weaver D, Zeldovich K, and Theurkauf W. Modernizing the Graduate Biomedical Curriculum. University of Massachusetts Medical School.

Raver S, Heintz M, Sisk C, DiCicco-Bloom E. Society for Neuroscience Efforts to Enhance Awareness and Knowledge of Scientific Rigor in Neuroscience Trainees. Society for Neuroscience, Michigan State University, Rutgers Robert Wood Johnson Medical School.

Varvayanis S, Holmes C. Collaboration Yields a Change of Culture to Enable Professional Development as an Integral Part of PhD Training. Cornell University.

Workshop 3: Published Resources

Allum JR, Kent JD, McCarthy MT. Understanding PhD Career Pathways for Program Improvement: A CGS Report. Council of Graduate Schools. 2014.

CGS Global Summit. What Is a Doctorate? A Statement of Practical Actions. 2016.

Dasgupta S, Symes K, Hyman L. Leading Change: Curriculum Reform in Graduate Education in the Biomedical Sciences. Biochem Mol Biol Ed. 2015.

Denecke D, Feaster K, Stone K. Professional development: Shaping effective programs for STEM graduate students. Council of Graduate Schools. 2017.

Gibbs KD Jr. Analysis of NIGMS Request for Information on Strategies for Modernizing Biomedical

Graduate Education. National Institute of General Medical Sciences. 2016.

Gould J. How to build a better PhD. Nature. 2015, 528:22-25.

Lorsch JR, Nichols DG. Organizing Graduate Life Sciences Education around Nodes and Connections. Cell. 2011, 146:506-509.

Mason JL, Johnston E, Berndt S, Segal K, Lei M, Wiest JS. Labor and skills gap analysis of the biomedical research workforce. FASEBJ. 2016, vol. 30.

Rodenbusch SE, Hernandez, PR, Simmons SL, Dolan EL. Early Engagement in Course-Based Research Increases Graduation Rates and Completion of Science, Engineering, and Mathematics Degrees. CBE-Life Sci Ed. 2016, vol. 15.

Zerhouni E, Berg J, Hrabowski FA, Kington R, Landis S. Training the Workforce for 21st Century Science: A Vital Direction for Health and Health Care. National Academy of Medicine Perspectives. National Academies of Medicine. Perspectives. 2016.

Workshop 4: *How to Increase the Engagement of Private Sector and Other Potential Employers in Training Paradigms and Opportunities.*

Engaging the private sector in biomedical education and training is critical in light of the fact that most biomedical PhD recipients will pursue careers outside of academia (NIH Biomedical Workforce Report, 2012). The goal is to improve doctoral education and postdoctoral training to make the training experience of graduate students and postdoctoral fellows more relevant to their career paths. One approach is to create opportunities for experiential training outside the research laboratory. Incentives and barriers to providing students and postdoctoral fellows with career-focused learning should be identified, including, but not limited to internships, externships, co-ops and other possible formats) should be identified. Implementable practices from successful programs should be shared.

Prior discussions of internship programs for graduate students and postdocs have focused solely on the benefit to the student or postdoctoral fellow. Building programs that have mutual benefit to the trainee, the university and the external partner are likely to be the most sustainable. Benefits for institutions include closer ties with employers, such that programs are more responsive to industry needs. Benefits for employers include the ability to hire Ph.D. scientists with a better match of needed soft-skills. Benefits to the trainee include a deeper understanding of their career trajectory and awareness of the non-academic work environment.

Recommendations

Institutional

1. *Collect and share data about experiential learning opportunities (career outcomes, time to degree, publications, etc.)*
   Presently, data supporting the value of internships for PhD scientists are not available. Before pursuing efforts at large-scale adoption, it is paramount to gather robust data on the impact that career-related internship programs have on all stakeholders. Evidence demonstrating the value of these experiences should include information about the role of experiential learning in preparing Ph.D. scientists for the job market and metrics on the impact of such experiences on the time to degree and research productivity. Additionally, information on perceptions of job readiness and performance of doctoral-level employees who did and did not have experiential opportunities would be valuable.

2. *Increase engagement of external partners in career development*
   (Few industry representatives were present in this workshop. A richer conversation would result from the participation of a broader cross-section of stakeholders.) Employers of PhDs have regularly opined that new graduates lack some critical skills required for success in the 21st century workplace. Some of these skills are best learned through internships and Co-Op style experiences. External partners are best positioned to help draft the learning objectives of these programs to reflect their common needs. Professional areas in which new PhDs are often lacking include project management, financial knowledge, communication skills and working in collaborative teams (Corey Valente - 3/23/17 NAS

hearing). Increasing the involvement of industry representatives will help ensure that trainees have the skills desired by potential employers.

3. *Encourage faculty support of experiential learning opportunities as an integral part of graduate education and postdoctoral training*
   There are several challenges related to experiential learning opportunities and their uptake by training faculty and graduate programs. The major barrier among training faculty are concerns about time away from the laboratory and the potential for slowing research progress. Structures should be created within individual laboratories and graduate programs that are conducive both to continued productivity in the lab and concomitant career development/career exploration. These activities should not require more than one-day-per week commitments. Alternatively, engagements, such as volunteer consulting, could occur outside normal working hours (Schillebeeckx et al., 2012). On-site career exploration may work well in large cities, where major employers are based, whereas this format may not be conducive to universal adoption, given the asymmetric distribution of partner organizations.

4. *Create a clearinghouse for best practices (preparation for internship, NDAs, MOUs, scope of work, evaluations) and experiential learning opportunities*
   There is a significant activation barrier to launching an effective experiential learning or internship program. If these activities are to be broadly available nationwide, standardizing templates for required paperwork and establishing best practices for establishing successful partnerships would help institutions overcome this initial barrier. While documents like non-disclosure agreements and memoranda of understanding will need to be customized, having standard templates from which to work would allow more programs to efficiently adopt these activities.

5. *Create national and widely representative working groups to facilitate data collection on experiential opportunities.*
   It is not yet clear what evidence, both easily collected and sufficiently robust, will encourage programs to develop internship experiences for doctoral trainees. The clearest data would be a longitudinal analysis relating internships to job satisfaction and career preparation and long-term success in the chosen track. However, such longitudinal data are difficult to collect and rarely have good control groups, making interpretation and analysis potentially ambiguous. More attainable would be a survey of career preparation distributed to employers of newly PhDs, some of whom had participated in PhD-level internships and others who had not. Many NIH-funded BEST programs have adopted internships and thus might provide natural study groups to follow as they enter the workforce (Mathur et al., 2015).

6. *Federal funding agencies should promote policies that encourage time for professional development/career exploration, and they should be specific in their guidance regarding what fraction of time is appropriate.*
   Faculty must certify that trainees paid on federal research grants are devoting their time exclusively to research. This requirement often leads faculty and program directors to be unsupportive of doctoral trainees spending time on career preparation activities, such as internships and other forms of professional development. Specific guidance from the funding agencies regarding the type and nature of allowed career development activities will clarify make it possible for institutions to structure career development programs to explicitly meet NIH, NSF, and other funding guidelines.

Workshop 4: *What Works* Abstracts

Chow CS, Feig Al, Kenaga H, Moldenhauer JA, Ouellett ML, Straub V, and Mathur A. Incorporation of internships and experiential career exploration to doctoral programs through the Wayne State University BEST program.

Fry CL. Fostering Partnerships with Industry in Graduate Training. American Society for Pharmacology and Experimental Therapeutics.

KozlowskiL , Chernets N, and Grunwald G. Engaging the Private Sector and Enhancing Our Graduate

Education and Postdoctoral Training Core. Thomas Jefferson University.
Merluzzi AP. Internships and Networking as Avenues to Bridge the Gap between Education and Employment. University of Wisconsin.

Schnoes A, Caliendo A, Morand J, Dillinger T, Naffziger-Hirsch M, Moses B, Crew C, Gibeling JC, Yamamoto K, Lindstaedt B, McGee R, O'Brien T. Graduate Student Internships for Career Exploration. UC San Francicso, iBiology, Northwestern University, UC Davis, Oakton Community College.

Scott KEN, Fernandez MR, Cook LM, Costello TJ. Non-Traditional Internships for Postdoctoral Fellows. Moffitt Cancer Center and Research Institute.

Tetzlaff J, Clifford PS. Engaging the Private Sector in Business Consulting, Education, Networking and Mentoring. Medical College of Wisconsin.

Workshop 4: Published Resources

Allum, JR, Kent JD, McCarthy MT. Understanding PhD Career Pathways for Program Improvement: A CGS Report. Council of Graduate Schools. 2014.

What is a Doctorate? CGS Global Summit of Practical Actions. 2016.

Mercer T. Careers in bioscience. Nature. Vol. 541. 2017.

National Network of Business and Industry Associations. A Foundation for Success in the Workplace. 2014.

Iyer LR, Sriram S. The right track for you in biotech and biomedical sciences. Nature Biotech. Vol. 33(10). 2015.

The Coalition of State Biosciences Institutes. Life Science Workforce Trends Report. 2016.

Mason JL, Johnston E, Berndt S, Segal K, Lei M, Wiest JS. Labor and skills gap analysis of the biomedical research workforce. FASEBJ. 2016.

Woolston C. Non-profit work: Take my advice. Nature. 2016, 532:531-533.

Zerhouni E, Berg J, Hrabowski FA, Kington R, Landis S. Training the Workforce for 21st Century Science. National Academy of Medicine. 2016.

Zusi K. Breaking Out of the Academic Pipeline. Cell. 2016, 165:1557-1559.

Workshop 5: *What Data on Master's and PhD Students and Postdocs Can Be Collected Nationally and Used to Inform Trainees and Training?*

The 2014 Council of Graduate Schools' report, "Understanding PhD Career Pathways for Program Improvement," laid out a clear and persuasive rationale for tracking career outcomes: transparency for prospective students and postdocs, improvement of program curricula, development of institution-wide programming, and development of faculty mentoring. There exists widespread consensus on the imperative to collect, analyze and report career outcomes for graduate students and postdoctoral trainees in biomedical sciences. Actions should focus separately on PhD students, postdoctoral scholars, Master's students and alumni of each career stage. Discussions should address what information should be collected about trainees, who will be the audiences for this information, and how it will be used to influence curricula, co-programming, mentoring, and other best practices in biomedical research training. Numerous schools have already begun this effort, and various coalitions are working together to develop common and consistent methodologies for classifying and reporting job types within multiple sectors of the workforce.

Recommendations

1. *For Master's degree recipients, the top priority for data collection is salary of first job placement*
   Master's students are a less studied and less well-understood population of biomedical workforce trainees. Data should be collected for students who withdraw from Ph.D. programs with Master's degrees (see above) and those who graduate from stand-alone Master's degree programs. This information could be collected via an exit survey that records the first job after receipt of degree and starting salary. This information will help assess the return on investment for stand-alone master's

programs and reveal the merits and drawbacks of leaving a Ph.D. program.

2. *For PhD students, the most important consideration is collecting and reporting data about degree completion*
   This category would include time-to-degree and attrition rates, both of which can be determined from institutional record keeping. For time-to-degree, it is essential to develop and adhere to a common standard method of calculation; medians and ranges should be reported. Time-to-degree and attrition rates should be broken out by program, URM/non-URM, gender, and citizenship. Attrition rates should include those who withdraw from Ph.D. programs with and without master's degrees. Those leaving with Master's degrees should be tracked throughout their careers in the same manner as alumni who complete the Ph.D. These data will help shape the curricula and expectations of graduate programs as well as defining co-curricular offerings in career exploration and planning (see previous section).

3. *For postdoctoral fellows, collecting demographic data is the first priority, specifically: URM/non-URM, gender, age, and citizenship.*
   Many institutions struggle to identify their postdoctoral populations, and national estimates are widely recognized to be unreliable (e.g., National Academy of Science, 2014). A collective effort to learn about who postdoctoral fellows are is the first step to providing them with the services they need to prepare for and enter meaningful careers. The demographic data listed above should be available from institutional records and should not require surveying individual postdoctoral fellows or alumni.

4. *Collect data from and about trainees at the institutional level and, then report up to form a national aggregate*
   Institutions want access to data about their own trainee populations to drive curricular reform, to develop co-programming, support local initiatives and compare trainee data with those of other institutions and with a national statistical portrait. It was strongly recommended that national statistics be aggregated from institutionally-collected data. These data would be more useful, more reliable, and more efficiently gathered than current efforts based on national surveys (e.g., NSF suite of national surveys: Survey of Earned Doctorates, Survey of Doctoral Recipients, Early Career Doctorate Survey). The National Science Foundation should consider (a) replacing its national data collection efforts with an aggregation of locally collected data and (b) redirect its financial resources to allocate funds to participating institutions to help support their data collection efforts.

5. *Institutions must agree to develop and use consistent and reproducible methodologies of data collection and systems of data reporting, and institutions must agree to report the results of these data collection efforts on public websites.*
   Aligning collection methodologies and reporting systems will ensure that data can be compared and aggregated across institutions. Transparency depends on public reporting. One of the main goals of collecting, analyzing, and reporting the data sets described above is to provide prospective students and postdocs with clear information about degree completion rates for PhDs, demographics for postdocs, starting salaries for master's, and career outcomes for all.

Workshop 5: *What Works* Abstracts

Eberle SK. What Is the Value of Graduate Education? Stanford University.

Fuhrmann CN, Thompson MN, Hall S, Imbalzano AN, Zamore PD. Short- and Long-Term Outcomes as Measures for Phd Career Development. University of Massachusetts.

Heckler E, McConnell S, Westerman E, Pierre J, Schwartz N. Collecting National Postdoc Data: Incorporating a Grassroots Approach. University of Chicago, Univesity of Arkansas.

McDowell GS. Transparent Trainee-Driven Data Collection. Future of Research.

Owen-Smith J. Data Driven Approaches to Tracking Postdocs – What Works. University of Michigan Institute for Social Research.

Stayart A, Baas T, Barbercheck C, Brandt P, Chalkley R, Duncan D, Gould K, Hutto T, Labosky P, Lindstaedt B, Mathur A, Meyers F, Steele S, Wefes I, Wilkinson K. Constructing a Taxonomy for Career Outcome Reporting. NIH BEST Training Consortium.

Workshop 5: Published Resources

AAMC. Institutional Approaches to Tracking Research Trainee Information. 2015.

Allum, JR, Kent JD, McCarthy MT. Understanding PhD Career Pathways for Program Improvement: A CGS Report. Council of Graduate Schools. 2014.

Garrison HH, Justement LB, Gerbi SA. Biomedical science postdocs: an end to the era of expansion. FASEBJ. 2015.

Mason JL, Johnston E, Berndt S, Segal K, Lei M, Wiest JS. Labor and skills gap analysis of the biomedical research workforce. FASEBJ. 2016.

Pool LR, Wagner RM, Scott LL, RoyChowdhury D, Berhane R, Wu C, Pearson K, Sutton JA, Schaffer WT. Size and characteristics of the biomedical research workforce associated with U.S. National Institutes of Health extramural grants. FASEBJ. 2016.

Silva EA, Des Jarlais, C, Linstaedt B, Rotman E, Watkins ES. Tracking career outcomes for postdoctoral scholars: a call to action. PLoS Biology. 2016.

UCSF Graduate Division. Identification and classification of Ph.D./postdoc career outcomes. 2016.

TABLE 1

WORKSHOP	RECOMMENDATIONS
1. How better to increase the diversity of scientists in senior and leadership roles	1. Start leadership training early – focus on students and postdoctoral fellows 2. Provide incentives and awards that enhance diversity, equity and inclusion 3. Change review practices - recruiting, hiring, promotion, funding, publications and awards 4. Require inclusivity training for all stakeholders
2. How to increase engagement and skills of trainees and faculty in mentorship	1. Train Mentors 2. Train Mentees 3. Market the value of mentor training 4. Encourage trainees to seek multiple mentors and build networks
3. How to modernize (and keep updating) curricula and training while maintaining the basic tenets of research and scholarship	1. Identify and refine key concept inventories and competencies 2. Define desired outcomes 3. Determine effective learning strategies 4. Map learning to the full training continuum 5. Address barriers to curriculum change 6. Integrate regular assessment of effectiveness 7. Bring the discussion of competencies to stakeholders 8. Establish national repository of resources
4. How to increase the engagement of the private sector and other employers in bioscience training	1. Collect and share data of career outcomes 2. Increase engagement of external partners in curriculum development 3. Encourage faculty support of experiential learning. 4. Develop clearinghouse for best practices 5. Develop working groups for data collection
5. How to collect national-level data on Master's and PhD students and postdocs, and how to use these data to inform trainees and bioscience training.	1. Masters students - Salary of first job placement 2. Doctoral students – Degree completion 3. Postdoctoral trainees - Demographics 4. Collect data at institutional level and report up to form a national aggregate 5. Institutions must use consistent and reproducible methodologies of data collection

REFERENCES

Alberts B, Kirschner MW, Tilghman S, Varmus H. Rescuing US biomedical research from its systemic flaws. Proc Natl Acad Sci U S A. 2014; 111(16):5773-7.

Broadening Experiences in Scientific Training Initiative (BEST).

Council of Graduate Schools, Understanding PhD Career Pathways for Program Improvement; 2014.

Daniels R.J. A generation at risk: young investigators and the future of the biomedical workforce. Proc Natl Acad Sci U S A. 2015; 112:313-8.

Fuhrmann, C.N. Enhancing Graduate and Postdoctoral Education to Create a Sustainable Biomedical Workforce. Hum Gene Ther. 2016; 27, 871-879.

Gibbs KD Jr, McGready J, Bennett JC, Griffin K. Biomedical Science Ph.D. Career Interest Patterns by Race/Ethnicity and Gender. PLoS One. 2014; 9:e114736.

Innovations in Graduate Education Program (NSF).

Kimble J, Bement WM, Chang Q, Cox BL, Drinkwater NR, Gourse RL, Hoskins AA, Huttenlocher A, Kreeger PK, Lambert PF, Mailick MR, Miyamoto S, Moss RL, O'Connor-Giles KM, Roopra A, Saha K, Seidel HS. Strategies from UW-Madison for rescuing biomedical research in the US. Elife. 2015; 4:e09305.

Mathur, A., F. Meyers, T. O'Brien, R. Chalkley, and C. Fuhrmann. 2015. Transforming training to reflect the workforce. Sci Transl Med. 2015; 7, 285.

Lee, S., Pfund,C., Branchaw, J., and McGee, R. Mentoring Up: Learning to Manage Your Mentoring Relationships. In The Mentoring Continuum: From Graduate School Through Tenure. 2015. Glenn Wright, ed. Syracuse, NY: The Graduate School Press of Syracuse University.

Levitt M, Levitt JM. Future of fundamental discovery in US biomedical research. Proc Natl Acad Sci U S A. 2017 114:6498-6503.

McDowell GS, Gunsalus KT, MacKellar DC, Mazzilli SA, Pai VP, Goodwin PR, Walsh EM, Robinson-Mosher A, Bowman TA, Kraemer J, Erb ML, Schoenfeld E, Shokri L, Jackson JD, Islam A, Mattozzi MD, Krukenberg KA, Polka JK. Shaping the Future of Research: a perspective from junior scientists. Version 2. F1000Res. 2015; 3:291.

McGee, R. Biomedical Workforce Diversity: The Context for Mentoring to Develop Talents and Foster Success Within the 'Pipeline'. AIDS and Behavior. 2016; 20:231.

National Academies of Sciences, Engineering and Medicine, The Postdoctoral Experience Revisited, 2014.

National Academies of Sciences, Engineering, and Medicine. Effective Mentoring in STEMM: Practice, Research, and Future Directions: Proceedings of a Workshop–in Brief. Washington, DC: The National Academies Press. 2017.

National Institute of General Medical Sciences, Investing in the Future, 2011.

National Institutes of Health, Biomedical Research Workforce Working Group Report, 2012.

National Postdoctoral Association Core Competencies.

NRMN (National Research Mentoring Network).

Pfund, C., Byars-Winston, A., Branchaw, J., Hurtado, S., Eagan, K. 2016. Defining Attributes and Metrics of Effective Research Mentoring Relationships. AIDS and Behavior, 2016; 20(2), 238-248.

Pfund, C., House S, Asquith P., et al. 2014. Training Mentors of Clinical and Translational Research Scholars: A Randomized Controlled Trial. Acad Med. 89: 774-782.

ACKNOWLEDGEMENTS

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FOBGAPT 1 Acknowledgements

The organizing committee thanks the following individuals for their help: Laura Avery, Susan Campos, Marc Williams - Rackham Graduate School; Maria White, Kara Gavin – Department of Communication; Kierstin Fiscus, Lisa Gubacci-Root, - School of Medicine; Susan Schaefgen, Jesse Geer – Conference Services. The conference was supported in part by contributions from the University of Michigan, the UM Medical School, the UM Rackham Graduate School, and Wayne State University's BEST Program.

FOBGAPT2 Acknowledgements

The organizing committee thanks the following individuals for their help:
Jim Finster, Matthew Berta, Susan Nagel, Lauren Field, Brian Meara, Elyse Rubin, and Pat Goggans. Financial support was provided by the University of Colorado Denver/Anschutz Medical School, the University of Michigan Rackham Graduate School, and conference grant R13 GM123651 from the National Institutes of General Medical Sciences.