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DIVERSITY IN THE BIOMEDICAL RESEARCH WORKFORCE: DEVELOPING TALENT

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Abstract

Much has been written about the need for and barriers to achievement of greater diversity in the biomedical workforce from the perspectives of gender, race and ethnicity; this is not a new topic. These discussions often center around a 'pipeline metaphor' which imagines students flowing through a series of experiences to eventually arrive at a science career. Here we argue that diversity will only be achieved if the primary focus is on: what is happening within the pipeline, not just counting individuals entering and leaving it; de-emphasizing achieving academic milestones by 'typical' ages; and adopting approaches that most effectively develop talent. Students may develop skills at different rates based on factors such as earlier access to educational resources, exposure to science (especially research experiences), and competing demands for time and attention during high school and college. Therefore, there is wide variety among students at any point along the pipeline. Taking this view requires letting go of imagining the pipeline as a sequence of age-dependent steps in favor of milestones of skill and talent development decoupled from age or educational stage. Emphasizing talent development opens up many new approaches for science training outside of traditional degree programs. This article provides examples of such approaches, including interventions at the post-baccalaureate and PhD levels, as well as a novel coaching model that incorporates well-established social science theories and complements traditional mentoring. These approaches could significantly impact diversity by developing scientific talent, especially among currently underrepresented minorities.

Keywords

Coaching; Biomedical Diversity; Graduate School; Individualized Development Plan; Intervention; Mentoring; Postdoctoral Researchers; Social Cognitive Career Theory; Underrepresented minorities

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ongoing outcomes evaluation. Compared to the general U.S. population, African Americans, Hispanics and Native Americans are severely underrepresented in the science, technology, engineering, and mathematics (STEM) fields and, consequently, the biomedical research workforce. In 2010, Hispanics, African Americans and Native Americans, together, represented over 30% of the U.S. population. The growth in the Hispanic population between 2000 and 2010 accounted for more than half of the growth exhibited by the whole U.S. population while those categorized as White-only by the census exhibited the least growth [1]. Yet, less than 9% of STEM PhD recipients in recent years are members of these three groups. Therefore, it is more important than ever to enhance development and retention of the full diversity of groups in our own population in the scientific workforce in order to maintain the manpower needed for competitiveness in the global marketplace [2], [3],[4].

> [Callout] The need for greater participation of all racial and ethnic groups of our population in the biomedical workforce is more evident than ever, but as we will discuss, many challenges to achieving this goal remain. Meeting these challenges will require continued innovative modifications and enhancements of the research training models that we use as well as ongoing outcomes evaluation.

In addition to workforce needs, diversification of the biomedical workforce will help address the critical need the U.S. faces to reduce racial and ethnic health and health care disparities. These problems have devastating human consequences and also negative economic repercussions. Underrepresented minorities (URM) are more likely than others to be familiar with, and highly motivated to ameliorate, health issues faced by their demographic groups, as has been shown for URMs in medical school training [5]. Therefore, expanding the number of minority researchers is expected to importantly contribute to reducing racial/ ethnic-related disparities [6],[2]. Finally, the importance of a diverse biomedical workforce is supported further by a significant body of evidence indicating that diversity strengthens the STEM talent pool and ultimately contributes to greater innovation and productivity in research settings in which team members engage in cooperative problem-solving [7],[8].

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In 2005, the National Research Council (NRC) conducted an assessment of National Institutes of Health (NIH)-sponsored diversity focused research training programs [6]. The report concluded that three decades of programs designed to increase diversity had promoted entry of URMs into the biomedical workforce, but major gaps remained, and the programs' effectiveness was more evident at the Bachelor's and Master's than at the doctoral degree level (PhD, MD/PhD and other dual degree holders). Recently cited statistics indicate, for example, that while in 2006, Hispanics and African Americans accounted for 15.0% and 14.1% of the U.S. population, respectively, they earned only 5.2% and 2.5% of the doctoral degrees in STEM fields awarded to U.S. citizens and permanent residents in 2007 [2]. The gaps are even larger if the doctorates awarded to all recipients, including temporary U.S. visa holders, are included in the analysis. Equally if not more troubling is the finding of a sharp drop-off among URMs at the postdoctoral and junior faculty levels in the 2005 report [6]. Finally, a recent study of the success rates for funding of NIH research (R01) awards found evidence of significantly lower success rates among African American, Hispanic and Asians compared to White applicants [9],[1]. Many of the differences could be accounted for by addressable differences in training experiences, but a portion of the difference for African Americans was not readily accounted for. Ongoing study and deeper analysis of this observation are certainly required, but possible explanations could include conscious or unconscious bias, or 'cumulative advantages' afforded to white scientists during their training [10].

So why has diversification of the STEM workforce been so difficult to achieve, especially at the PhD and professional levels? We believe it is at least partially the result of inadequate recognition of and attention to the extreme and lasting effects of educational disadvantages and socioeconomic status (SES) on a high fraction of URM students, the pool from which new STEM workers must be drawn. SES and URM status add to and are at least as impactful as ongoing racial and ethnic discrimination and bias. Their dual impacts have marked influences on students attempting to develop their talents throughout the 'pipeline.'

The STEM pathway from college to a doctoral program and then entry into a professional career has traditionally been referred to as a pipeline. Flow through a pipeline evokes an image of a uniform fluid flowing at a uniform speed, with leaks depicting failure to keep up with the flow. This imagery fails to capture: the incredible heterogeneity of individuals within the scientific pipeline; the developmental processes that add to or decrease progression of individuals; and the varied levels of skills each has developed as they pass the traditional academic stage milestones. In other words, the pipeline analogy can easily distract from a focus on the different starting points of those who enter it and the development of talents that does or does not occur within it.

The first step usually discussed for increasing output from the pipeline is to markedly increase the number of individuals from URM groups who successfully pursue science majors as undergraduates [11]. However, a nuanced approach is needed to increase the numbers of URM undergraduates who exhibit interest in science to be successful enough in pursuit of their STEM studies to retain that interest. A much higher fraction of minority students attend high schools with lower capacity to provide the level of education afforded non-minority students, leading to unequal access to high-level math and science courses and disparities in college readiness [12],[13]. Even the most talented URM students in these settings do not have the opportunity to fully develop their potentials. Thus, a high number start college with significant educational disadvantages to overcome. Changing this disparity will require radical improvements in science and mathematics education as well as general academic skills across the K-12 education system. Efforts are being made to move toward positive change, including specific K-12 efforts aimed at diversity and special research programs for high school students [14],[15]. However, such change in K-12 education will at best be too slow to impact the workforce for decades. Educators, researchers, and policy-makers have therefore also focused on identifying crucial points throughout the pipeline at which national-level interventions and policies geared to attract and retain URMs pursuing biomedical research careers provide support programs and resources to facilitate their 'catching up' with higher-resourced peers. There is much left to achieve since, although minority undergraduates initially express similar levels of interest in STEM fields as the general student population, far fewer stay on that path and graduate with undergraduate degrees in STEM [16],[17]. Next we describe our approach, which refocuses the pipeline metaphor by including greater emphasis on development of potential talent and discuss several specific programmatic efforts that endeavor to do so.

REFOCUSING PIPELINE METAPHOR: DEVELOPMENT DURING TRANSIT

A literal interpretation of the pipeline metaphor depicts a rigid conduit in which students are lost at every level of education, i.e. a pipeline that cannot easily expand and which has metaphorical leaks that are in need of patching all along the way [18],[11]. The success of many past and current efforts to increase the numbers of URM students entering and retained in the pipeline have worked to increase awareness of science careers and promote development of the skills of those who start the journey. But the size of the pool of potentially interested students who come from high-resourced environments is small and shows no signs of expanding soon. Thus, increases in the number of students at the start of the pipeline will have to come from under-resourced students who will require intensified and novel approaches to developing them as future scientists compared to more resourced students. Clearly, just providing ‘opportunities’ to experience science will do little to change their ability to keep up with, or accelerate, into the flow of other students. They will require more time in transit (time to degree and time between degrees) to catch-up, and focused approaches to developing critical skills that may not have been targeted in their earlier education. But for many, those skills are there waiting to develop. In our approach, more akin to developing athletic or artistic talents, those responsible for guiding development of talents act as skilled coaches. From this perspective, the pipeline is filled with talent to be developed and increased emphasis must be placed on providing ongoing, active guidance rather than relatively passive provision of experiences.

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As already noted, at the start of college, there is likely to be a disparity among those entering. Many more URM college students come from lower SES and have had fewer educational advantages from K-12 education, thus, at this stage, they begin with their talents less fully developed. A higher fraction of these undergraduates have started out in two-year colleges [19]. Even as they complete undergraduate degrees, a much higher fraction of URM students are not sufficiently prepared to go directly into PhDs and do MS degrees first [20], [21]. Many students in strong undergraduate settings are unable to enjoy the full benefit of these settings because of ongoing challenges not faced by most of their majority classmates, e.g. economic resources, family responsibilities, insufficient mentoring [22],[23].

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Economic challenges combined with family responsibilities often necessitate long work hours and prevent students from accepting offers into specialized programs because the program stipend could not meet their financial needs. As they approach graduation from college, there are a significant number of students who thus have unrealized potential that can be missed because they have not yet had the time or guidance to develop the analytical skills required for doctoral training.

Development of identity and self-efficacy as a scientist, which is posited to foster interest in and persistence toward research as a career, depends on the quality of the research experiences and related problem-solving exercises that are provided to students as experiential elements on which to build [24],[25],[11],[26]. Undergraduate pipeline programs must have the ability to assume some risk and develop the ability to identify and recruit URM students who exhibit persistence and enough untapped talent to enable them to succeed in intensive research education. They must then support and motivate them to pursue science careers by means of well-designed initial projects and programs. Focusing only on those with documented ability that needs a little honing will not expand the talent in the pipeline toward the biomedical research workforce although honing and maintenance of interest of these students is important. Identification of additional students with potential talent is a critical element in this process and experiences of biomedical PhD program directors have verified that conventional measures of achievement simply are not predictive of success for URM applicants with non-traditional backgrounds. This important issue has been raised by programs that transition URM students into PhD programs [20] and must be carefully considered for earlier pipeline programs, from which it may become possible to extract meaningful data on "late bloomers," i.e. development of latent talent. It is critical to note that identifying and developing talents among majority students who also have non-traditional backgrounds is just as important as it is for URM students [27].

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CURRENT EFFORTS TO INCREASE DIVERSITY IN SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS PROGRAMS

Overview

The vast majority of diversity-focused student development programs have focused on the undergraduate years. Programs usually focus on three primary objectives: 1) raising awareness of, and interest in, scientific careers among students who have no knowledge of these careers; 2) increasing the number of students completing bachelor's degrees in a STEM discipline; 3) developing talents of students so they have the necessary skills to be successful in graduate degree careers. At the college level, a combination of academic and social support, mentoring, stipends for doing research, tutoring, exam preparation, graduate school advising and preparation, summer bridge experiences, research opportunities, and career and skills development activities are standard for most of these programs [28],[11],[29]. But they usually are very constrained within the boundaries of the number of credits that lead to the bachelor's degree. Thus, emphasis can be on minimizing 'transit time' in this stage of the pipeline rather than 'time to develop talents' as the best endpoint. Structured programmatic interventions targeting URMs in the undergraduate setting incorporate a substantial and systematic mentoring and coaching by program leaders to complement or supplement mentoring provided by faculty [28]. This combination of efforts assists talent development and sustains scientific aspirations and preparation for further graduate training. However, it is seldom recognized that more highly resourced, usually non-URM, students also continue to develop skills at a rapid rate during college. Thus, from a perspective of time required for skill development, under-resourced students may not yet have made up for earlier disadvantages by the time they graduate.

Diversity Programs Focused Primarily on Undergraduates

Federal support for a substantial portion of diversity initiatives is provided through the NIH National Institute of General Medical Sciences (NIGMS) and the National Science Foundation (NSF). Among the NIGMS programs at the undergraduate level are the Minority Access to Research Careers (MARC) and Research Initiative for Scientific Enhancement (RISE) programs, which are institutional grants that are most commonly awarded to colleges and universities with a major undergraduate teaching mission and high URM student enrollment. However, recent policy changes have expanded institutional eligibility for MARC grants. By contrast, the Initiative for Maximizing Student Development program (IMSD) provides institutional awards at research-intensive universities, and the IMSD programs can focus on undergraduate students, PhD students, or both. NSF programs, including the Louis Stokes Alliances for Minority Participation (LSAMP) and others directed at colleges and universities that have historically served African Americans or Native Americans, have provided funding for and fostered transitions from pre-college to the STEM undergraduate degree to attainment of the doctorate and entry into the STEM professoriate. An evaluation of LSAMP by the Urban Institute in 2006 concluded that well-grounded program strategies and approaches contributed to the programs' meeting or exceeding their goals. Of interest in connection with talent development, the report also suggested that LSAMP increase its focus on students who start out in community colleges [30].

Non-federal interventions that aim to increase the number of URMs in biomedical research careers have also been initiated by academic institutions and the philanthropic or private sectors, often later obtaining federal funds. The philanthropist-founded Meyerhoff Scholars Program at the University of Maryland, Baltimore County, which initially targeted African Americans but has since expanded to include other groups, has graduated students in science and engineering at higher rates and facilitated their admittance to graduate schools at higher rates than comparable students who were selected into but elected not to enter the program through a combination of financial aid, a summer bridge program, academic tutoring, community service, study groups, mentoring, research internships, family involvement and other program elements with a demonstrated record of success [31]. This nationally-recognized model of an intervention program starts with highly talented students who have already risen above their peers and builds upon their existing talents to ensure their continued interest and success through an intense and often transforming academic and social environment [28].

Bridging Programs and Post-Baccalaureate Programs

Several NIGMS initiatives focus specifically on the often longer and more circuitous path of under-resourced students. The Bridges to the Baccalaureate program supports collaborations between 2-year or community colleges and 4-year baccalaureate programs to foster URM student development and success. The Bridges to the Doctorate program (collaborations between MS and PhD-level universities) recognizes the importance of supporting the development of the higher proportion of URM students who do the MS degree before the PhD. A novel variant of these programs is the Post-baccalaureate Research Education Program (PREP), an institutional award to universities or medical schools for a non-degree program that provides a full year (and sometimes two years) of additional research training and coursework to enable a student to excel in graduate studies; an example of this program will be described in detail below.

Programs Focused Primarily on Pre- and Postdoctoral Research Education

At the graduate and postdoctoral level, the primary focus of diversity efforts is financial in the form of individual fellowships and appointment of URM students to traineeships on institutional pre- and post-doctoral training grants funded by NIH under the Ruth L. Kirschstein National Research Service Award (NRSA). In addition, NIH provides supplements to research grants to support individual URM participants as summer students as well as pre- and postdoctoral students. NRSA and other individual awards typically rely primarily on classical mentoring for development, however, as noted earlier, the IMSD program can also be used to support more innovative graduate interventions. For example, the IMSD-funded program called Training and Education to Advance Minority Scholars in Science (TEAM-Science) at the University of Wisconsin-Madison integrates a comprehensive career development framework into graduate research training for URM doctoral students in the biological and biomedical sciences [24]. An in-depth discussion of the design elements of another IMSD program, the Collaborative Learning and Integrated Mentoring in the Biosciences (CLIMB) program at Northwestern University,, which focuses on career development activities during graduate training, will be featured below. Finally, the NSF’s Alliances for Graduate Education and Professoriate Program (AGEP) focuses on increasing the number of URMs obtaining graduate degrees in STEM and enhancing their preparation for faculty positions in academia. As one example, the ten-year report on the State University of New York Stony Brook’s AGEP outlines a comprehensive set of program strategies and elements that create a community of scholars [32].

BEYOND UNDERGRADUATE STAGE OF PIPELINE

Although research is available on STEM interventions at the K-12 and undergraduate levels, there is still a paucity of data on successful practices that are specifically at the doctoral level in minority STEM education [33] even though there have been significant recent attempts to increase data-based evaluations and research-based design of program elements [34]. Virtually no studies have rigorously looked at effects of early economic and educational disadvantages on education after the bachelor's level. Moreover, studies are needed to challenge the unspoken, or sometimes spoken, assumption that students from disadvantaged backgrounds can and/or must somehow close any remaining gaps during college even though those with 'cumulative advantage' [9] were also growing and developing during college. The progressive loss of URMs all along the path to doctoral degrees and successful entry into a biomedical science career provides evidence for the flaw in the logic, and brings to light the importance of greater efforts during PhD training to allow continuous development of these students' talents. Alternatively, it is possible to intercede during the post-baccalaureate time between college and PhD training and provide support during the PhD training to enable development of talents essential for success as a scientist. Below we describes examples of interventions at the post-baccalaureate and PhD level designed to attend to the disproportionate economic strains and insufficient mentoring, and 'seal the holes' past the undergraduate section of the pipeline, by focusing on retaining students in PhD programs [18].

POST-BACCALAUREATE RESEARCH EDUCATION PROGRAMS: PURPOSEFUL PAUSE BETWEEN ACADEMIC MILESTONES

Overall Description of Program Initiative and Applicants

In 2001, NIGMS funded the first eight Post-baccalaureate Research Education Programs (PREPs) [35]; there are now twenty-nine programs across the country. Eligible applicants to PREPs are students from URM backgrounds or persons with disabilities who completed a bachelor's degree within three years of applying to PREP, have not pursued other post-baccalaureate or graduate work, and express a strong interest in pursuing PhD or MD/PhD training in a biomedical sciences-related area upon completion of PREP. Applicants to PREP have a very broad range of prior research experience, from no actual hands-on research to several summers and/or semesters of research with opportunity to develop both technical and analytical skills. They also have a broad range of academic readiness for PhD work as assessed by their transcripts, profile on standardized tests, and recommendations. Some of them are clearly not yet prepared or do not feel prepared to step directly into a PhD program in which sophisticated analytical reasoning, as applied to research data, is expected to be already well-developed. Some PREP applicants applied earlier to PhD or MD/PhD programs but failed to gain acceptance and now want to enhance their research experience while also continuing to develop other skills that need further growth for the next round of applications. The applicants' stated goals for the PREP experience typically include: having a chance to focus intensely on research and academics without nearly full-time employment; changing research direction; addressing a perceived academic weakness; enhancing their credentials overall in order to gain acceptance to higher ranked programs; resolving uncertainty about whether to pursue a PhD or MD/PhD path.

All PREPs focus on an intensive research experience as the most important vehicle for developing scientific talent and acculturating to a biomedical research community. All programs work with participants to develop and pursue individualized development plans (IDPs) for research, academics, and other activities that will help them move toward their goals. Here we will profile the PREP at Mount Sinai School of Medicine, which was one of the original PREPs started in 2001, and highlight lessons learned that relate to development of talent. Mount Sinai PREP has grown from its original participant group of four participants in 2001 to ten participants in 2011; they pursue a mix of one- or two-year programs in PREP [36].

Mount Sinai Program: Admissions and Orientation

The applicant pool for Mount Sinai PREP has grown over the years to over 100 applicants for 5 openings in 2011. In selecting applicants for interview, Mount Sinai PREP looks for evidence of strong interest in research, recognition of any weak spots that need work, and persistence in pursuing challenging goals. The program interviews and accepts applicants whose records strongly suggest that they will be ready to apply to and succeed in excellent PhD or MD/PhD programs after 1–2 years in Mount Sinai PREP. The program also affirmatively seeks to interview and accept applicants whose potential to achieve readiness for such programs is less certain. Risk is taken for some applicants each year who show potential, but whose current quantitative, analytical or standardized test-taking skills are not yet in good alignment with stated goals for PhD or MD/PhD programs. Such applicants have been characterized by others as a ‘diamonds in the rough’ applicant group [37],[20], and the 2005 NRC report recommended that diversity programs expand their development of talent from this pool [6]. The program looks for evidence of exceptional persistence, which is often noted in recommendation letters or evident in personal statements that outline an applicant’s climb up a ladder of challenges. A genuine interest in research is also sought, but this can be difficult to evaluate in applicants with limited research experience, in which case the manner in which an applicant writes about discovery and career goals plays a bigger role. The Mount Sinai Graduate School supports on-campus visits for PREP interviews. The interviews provide an important opportunity to identify applicants, especially those ‘diamonds in the rough,’ who are resilient and coachable, and whose research interest is robust. At the interview, applicants meet two faculty interviewers with compatible research interests and the Program Director, in group and individual meetings, with the latter used to discuss how a PREP experience could be tailored to their goals. They also meet current PREP scholars and the PREP Steering Committee, which includes representation from leadership of the Graduate School, MD/PhD program, the Associate Dean for Diversity and Diversity Policy, a PREP alumnus, and six faculty members with different research interests.

Incoming PREP scholars share a mid-August orientation week with the other incoming groups, PhD, MD/PhD, MD, and master’s students; they share activities during this week, but each group also has individualized programming. Some PREP scholars start in June, with a course offered to incoming students from several programs who seek to enhance or refresh their mastery of biochemistry and molecular-cell biology. The June PREP entrants choose a research mentor and usually initiate research before formal orientation, while the PREP scholars entering in August choose their mentors during orientation. For all, the choice of research mentor is a guided process in which each PREP scholar identifies and speaks to a series of potential mentors and spends time in their laboratories talking with lab members. The choice is then reached in consultation with program leaders. During the early months of PREP, each PREP scholar initiates the self-inventory part of the IDP process, currently in the form of a written summary of short- and long-term goals; the skills they have; and skills they want to enhance in order to reach their goals. The skills survey includes: academic skills, research skills (technical, analytical), presentation, writing (including proposals), and their own skills as mentors. The action plans, which are then developed in consultation with the Program Director, include: research goals; courses; skills development through program elements and sometimes specially designed skills-development plans; and outreach and community activities that are of special interest. During this period, the PREP scholars also meet with Steering Committee members and adjunct advisors as well. All of these early conversations enable Program leaders to get to know the core goals and interests of each new PREP scholar as well as their broader interests, including outreach and volunteer activities. This builds relationships between the new PREP scholars and Program faculty, providing a touchstone between them that can ease the transition to a very new environment [38],[39].

Overall Program Elements

PREP scholars spend most of their time in their research laboratories and are encouraged to go to meetings at which they present their work; many become co-authors of research papers. They take the fall Responsible Conduct of Research with first-year PhD and MD/PhD students. They are invited to many of the graduate and medical student recreational and career development events as well as to events of the Center for Multi-cultural and Community Affairs (CMCA). All PREP scholars also participate in program elements which include: workshops on writing skills and application essays, time management, interview and re-visit strategies, presentation skills, etc.; works-in-progress sessions run by PREP alumni; and lunches with individual faculty members, PREP alumni, and visiting guests. PREP scholars are encouraged to take a graduate core-type course or some specialized course of interest to them. However, some PREP scholars with very strong academic records choose to focus on research and take no courses. Other PREP scholars choose to focus on getting a strong start in a new research laboratory and delay taking courses, which can be very challenging to some PREP scholars at their time of entry. Essentially all PREP scholars exhibit growth in their scientific skills, aided by courses, and participation in PREP research, journal clubs and works-in-progress.

Mount Sinai Alumni and Lessons Learned

Mount Sinai PREP now has 54 program alumni. Well over half have entered PhD or MD/PhD programs at Mount Sinai, throughout the country and one in London. They have competed well for fellowship and traineeship awards. Nine of those who entered PhD programs have completed the PhD degree and then entered excellent and diverse postdoctoral positions, after which one alumna entered a staff position at the FDA. Two PREP alumni in Mount Sinai's MD/PhD program have also completed their PhD degrees and are now in the clinical phase of the MD program. Six PREP alumni pursued lab jobs for a year or two before applying for graduate school, largely to stabilize their finances while gaining further research experience. So far, 77% of the PREP alumni who entered PhD or MD/PhD training are on track to complete their doctoral programs. Others changed directions, with most of them completing master's degrees in a variety of biomedical science areas and successfully entering the workforce.

Nine PREP alumni entered MD training, with the large majority of them still participating in research and planning to include translational, clinical or outreach-related research as part of their future careers. As their goals moved toward MD training during PREP, some retained their interest in translational bench research while others were helped to move to projects on health or health care disparities, evaluation of interventions with adolescents, and other patient-related research. Educational programs of Mount Sinai's Clinical and Translational Science Award have provided opportunities for the MD-bound students to take coursework and attend special workshops on research aspects of their emerging interests. Several PREP alumni who pursued MD degrees also completed an MPH degree. Finally, a small group of PREP alumni decided during their PREP experience that their skills and interests were best suited to seeking master's paths to prepare them for specific fields such as forensics, nanotechnology, nursing, or health care-related economics. One PREP scholar directly entered a pharmaceutical setting. Overall, data gathered from this group indicate a significant contribution of the PREP experience was developing their skills and helping them identify a rewarding career path.

One of the major lessons of the first ten years of Mount Sinai PREP is that most of the PREP scholars, who were accepted without certainty of their capacity to reach competitiveness for doctoral training while in PREP, displayed a distinctly rising curve in their academic and analytical research skills during PREP. This increase in skills continued in additional research years and/or their subsequent pre-doctoral training.

> [Callout] One of the major lessons of the first ten years of Mount Sinai Post-Baccalaureate Research Education Program (PREP) is that most of the PREP scholars, who were accepted without certainty of their capacity to reach competitiveness for doctoral training while in PREP, displayed a distinctly rising curve in their academic and analytical research skills during PREP. This increase in skills continued in additional research years and/or their subsequent pre-doctoral training.

Several of these students have also already completed outstanding dissertations and have completed postdoctoral positions in top research laboratories in their fields. This is a development of talent that was there waiting to be tapped. They are now ready to compete and contribute to biomedical sciences at a level that traditional predictors of success would not have indicated when they entered PREP. These observations mirror comments by others [40],[11] that development and expansion of the pipeline of URM scientists requires the investment of extra time for some to make up for early career disadvantages. It also requires expanding the definition of ‘qualified’ candidates beyond classical criteria thought to predict success.

A second lesson learned during the Mount Sinai PREP experience echoes the wisdom of many others [24] in recognizing the value and importance of multiple models developed by educational and social psychologists that create a framework that builds community among program participants and alumni. Such frameworks also inform the design of program elements that enhance career self-efficacy of participants, as will be discussed further in the next sections, and reduce feelings of isolation. From observations of Mount Sinai PREP we also note, as have others in different settings [41], the deep and pervasive importance to the PREP cohort of ongoing participation in outreach activities of their own. Almost all Mount Sinai PREP alumni report involvement in mentoring; program development; diverse volunteer activities; community and medically-related outreach efforts; and efforts to help respond to disasters affecting impoverished communities elsewhere.

> [Callout] From observations of Mount Sinai PREP we also note, as have others in different settings, the deep and pervasive importance to the PREP cohort of ongoing participation in outreach activities of their own.

A major deficit in efforts to increase biomedical diversity through programmatic interventions is our inability to pool data across programs to look for patterns of impact rather than smaller scale program evaluations. Until recently, there has been no national registry of students in programs; even NIH has not collected data from the programs they support in a way that allows for systematic study. That has recently changed through the requirement and ability to appoint all levels of NIH-supported trainings through a system called XTrain. Moving forward, larger scale outcome studies will be possible. Several studies previously referenced (17–20) have also studied large numbers of students in these programs and shown how they positively impact scientific identity and other measures of progress toward becoming a scientist. One of the studies being conducted by the Northwestern group is studying students in 6 PREP programs and is using qualitative interviews to study why students enter PREP programs instead of going directly to graduate school and the ways in which PREP programs impact students. Thus, many new insights into how intervention programs impact students considering science careers will be available in the future.

NEW APPROACHES TO DEVELOPING TALENT AT PHD LEVEL

Students start PhD programs with a wide range of acquired academic and scientific skills. As noted earlier, the skills of students coming from less advantaged backgrounds often are not as fully developed at the start of the PhD. Thus, they will be at higher risk of failing to thrive during the rapid transition of the first two years of the PhD. This reality underscores the value of PREP efforts, and it also supports the potential benefit of using new methods focused on talent development efforts during the early years of the PhD. At Northwestern University Feinberg School of Medicine (NU) the process of talent development has been informed by established theories and principles that underpin how people acquire skills and become recognized as legitimate members of a community, in this case the biomedical research community. In the following sections, we highlight one alternative approach to training, systematic coaching to complement traditional mentoring, and describe two of the projects of the Scientific Careers Research and Development Group (SCRDG) at NU [42] that incorporate coaching to support the early-stage development of young scientists. Although initiated from the perspective of enabling greater advancement by URM and women scientists, the principles and practices developed have a high level of relevance to all early scientists.

SYSTEMATIC COACHING AS CONTRAST TO TRADITIONAL MENTORING

Within biomedical research training, the method for achieving the development of scientific talents almost uniformly focuses on mentoring. By contrast, training of MDs and most other professions places primary emphasis on formal, systemized processes to maximize the probability that everyone acquires a prescribed core body of knowledge, skills and attitudes. Standardized tests assure these competencies are achieved. Research training is almost the exact opposite – an emphasis on informal teaching and learning experiences with a high level of variability. Working with mentors, most often thought of as one-to-one interactions, has historically been the cornerstone of research training. In theory, mentor-based training has great strengths: it is situated within the research environment and provides exposure to the research process; it allows for a high level of customization and individualization; it allows for developmental evolution as skills and competencies grow; and it overall aids in the socialization of students [43]. However, if one steps back and analytically considers mentoring as a construct within biomedical training, it also suffers from some major weaknesses: it assumes that mentors have time for and a high level of expertise with mentoring and quality control can be very difficult to monitor or influence. Additionally, minority mentees may find it difficult to connect with non-minority mentors who lack multicultural competence and knowledge regarding the educational and non-academic experiences of minority students [43]. To complement what young scientists may or may not get from mentors, we have turned to a more structured coaching approach.

The term ‘coaching’ engenders almost as many variations of a theme as does ‘mentoring.’ In our use, coaching refers to a more systematic process for teaching many of the skills scientists historically have been expected to learn from mentors. In this context, more use is made of group-based methods than is typical for mentoring, and the coach is purposely chosen for his or her expertise in teaching and developing the talents necessary for success as a scientist. The coach usually is not involved in the day-to-day research mentoring of those s/he is coaching, and most importantly, has no evaluative role with regard to student performance. Thus, many of the inherent conflicting interests of research mentoring are minimized, and relationships become more centered on conscious teaching and individual development. Below we provide examples of how we are applying principles of systematic coaching to biomedical research training, specifically with an eye to how it can potentially augment scientific development of less-resourced students and mitigate some of the other challenges to their success.

> [Callout] In our use, coaching refers to a systematic process for teaching many of the skills scientists historically have been expected to learn from mentors. In this context, more use is made of group-based methods than is typical for mentoring, and the coach is purposely chosen for his or her expertise in teaching and developing the talents necessary for success as a scientist. The coach usually is not involved in the day-to-day research mentoring of those s/he is coaching, and most importantly, has no evaluative role with regard to student performance.

COLLABORATIVE LEARNING AND INTEGRATED MENTORING IN BIOSCIENCES

The Collaborative Learning and Integrated Mentoring in the Biosciences (CLIMB) program is an example of the application of systematic coaching by individuals whose primary role is development of talent, rather than a primary role of doing research with mentoring/talent development on the side. It is designed as a professional development sequence for biomedical PhD students from the five bioscience programs at NU. It was initiated through one of the NIGMS diversity funding sources, the IMSD in 2007. Since then, it has evolved dramatically both in terms of its design and its current de-emphasis of CLIMB being relevant only to URM students. Initially, activities were essentially only for URM students, but this promoted the notion of it as a remedial or exclusionary program even though it never had a remedial design or intent. It also promoted isolation of URM students from other colleagues, again neither its intent nor its desire. From its inception, the activities were carefully focused on augmenting the development of skills necessary for a high level of success by all scientists, especially those skills that are unevenly taught by mentors during the first two years of PhD training. By the third year of the program, CLIMB was opened to all incoming PhD students (100–120 each year) in the five programs in addition to the six students funded by the IMSD each year. Within two years, voluntary participation in CLIMB had jumped to 20–30 students per year, and it had developed into a vibrant community of cross-disciplinary young scientists mutually supporting and assisting their growth and development.

> [Callout] The Collaborative Learning and Integrated Mentoring in the Bioscences (CLIMB) program is an example of the application of systematic coaching by individuals whose primary role is development of talent, rather than a primary role of doing research with mentoring/talent development on the side.

The design of CLIMB is carefully aligned with what is most critically important and of value to students at each point in time during the first two years of the PhD. It provides teaching of practical skills with the opportunity to practice them under the guidance of the Program Director and Assistant Director who have no involvement with evaluation or research mentoring of the students. Perhaps more than similar programs of this type, CLIMB focuses on the socialization and acculturation that must occur for a student to be accepted into and seen as legitimate within the scientific community. Space does not permit a full discussion of the theories that underpin the CLIMB approach, but they include Social Cognitive Career Theory [44],[45], scientific identity development [11],[25],[26], cultural capital [46], and communities of practice [47]. These theories contribute insights into how novices develop an image of themselves as members of the community, gain confidence in their skills within their new community, and navigate becoming fully accepted members.

This process of acceptance can be as challenging as the development of laboratory and computational skills and can be much more difficult for URM and other atypical students (including women) who have a higher risk of marginalization to a peripheral role [47].

Within CLIMB, the processes of acculturation are made explicit, rather than unspoken or unknown, through direct conversations and instruction about how skill development takes place within the context of becoming a member of the research community.

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For example, weekly meetings throughout the fall term focus on the transitions that everyone is going through, albeit in different ways: transitions from undergraduate to graduate student and the very different styles of teaching and expectations of learning; transitions from being a short-term undergraduate in a lab to a being assessed during rotations as a potential long-term lab member. The winter and spring of the first year focus on oral communication skills both from the standpoint of a key scientific skill and the critical role early impressions make as one establishes credibility in the community. We emphasize how a visual and oral presence is key to how students are perceived by others as future successful scientists. In the second year, CLIMB emphasizes development of scientific writing skills. In this case, the skill is related to its immediate usefulness: scientific writing for a fellowship or research proposal, for developing logical arguments, and designing appropriate research strategies. Clearly, these are skills all young scientists need to continuously develop and refine. Students at all starting skill levels improve, but we have observed that those with the least developed skills often develop the most. Thus, based on our observations, URM students coming from less advanced and advantaged starting points very commonly show the biggest gains.

While CLIMB has been purposefully designed taking into account social science theories, many of the other student development programs actually incorporate many of these considerations because the programs have been largely crafted by biomedical scientists who intuitively know what is important for success. However, much more could be done to analytically review programs globally or locally from these theoretical principles and look for ways to improve them. For example, some mentors and programs may take the view that it is important to expose students early on to the rigors of research and the probing, often harsh analysis of published literature. However, a novice with a minimally formed identity as a scientist who has minimal skill in this endeavor could prematurely come to the conclusion that they are NOT a scientist because they don’t know how to critique effectively. Later in their development they could be ready for this level of intensity but not early in their training.

ACADEMY FOR FUTURE SCIENCE FACULTY

Through an NIH Directors Pathfinder Award to Diversify the Scientific Workforce (R. McGee starting in 2010), we have embarked on a truly novel experiment to ask the question: is it possible to increase the probability that URM individuals achieve successful academic careers through systematic coaching to augment the idiosyncratic mentoring they receive during their training? This question focuses on probably the most intractable problem in all diversity work – the unbelievably slow improvement in racial and ethnic diversity in the ranks of college and university science faculty and the disappointing gap for some in NIH

R01 awards [9]. This study represents the expansion of the SDRDG basic research on career decisions of young scientists and the experimental application of social science theories to research training in a true experiment. In essence, we are hypothesizing that the social science theories provide new insights into why interventions to date, along with the idiosyncratic nature of mentoring, have failed to achieve expected improvement in faculty diversity. These theories also provide insights into how to counteract the many, small, and sometimes big, inhibitors to achieving a successful academic career for highly talented individuals from underrepresented groups.

> [Callout] Social science theories provide new insights into why interventions have so far have failed to achieve expected improvement in faculty diversity, providing insights into how to counteract the many, small, and sometimes big, inhibitors to achieving a successful academic career for highly talented individuals from underrepresented groups

The theories are the central core for the design of this novel intervention. Very briefly, in 2010, we recruited 11 highly skilled mentors and leaders of research training from around the U.S. to serve as coaches. Information on the Academy and an invitation to participate were distributed to as many biomedical PhD programs as could be identified to be sent to students starting their PhD in fall, 2011. The 350 students who applied were stratified by gender, race and ethnicity and then 100 were randomly assigned to become part of the Academy for Future Science Faculty (the Academy) and an equal number as non-treatment controls. Students in each group represent a wide array of PhD programs across the U.S., The students and coaches came together in July 2011 for a 3-day immersion of carefully constructed activities predicated on: the social science theories and their influences on scientific development; our deep knowledge of research training; and the benefit of creating a sophisticated community of colleagues to support and assist with their mutual success. After the meeting, each coach continued to engage with the group of 10 students through regular electronic communication throughout the year. Future training immersions in July of 2012 and 2013 will be structured to continue talent development and explicit socialization. A second arm of the study will recruit 6 new coaches and 60 new students in early 2012 for a similar 2-summer Academy, this time for students within one year of completing the PhD. Again, a randomized controlled trial design will be employed.

The Academy is being studied by a team of three PhD-level social scientists who are both contributing to its design and objectively studying its effects on both students and coaches. Obviously, it will be many years before we will be able to determine if the Academy has any true impact on achievement of an academic career, but there will be many near-term milestones we will be able to assess along the way. We hypothesize that Academy students will show an increased interest in and persistence toward research careers, and ultimately high success in achieving them as a result of the intensive and thorough grounding they receive from coaches which fills in the gaps or complements what mentors may or may not provide. We also hypothesize that by being taught the social science theories that underpin the often invisible and unconscious social processes that impact success they will be better able to navigate and guide their own success.

> [Callout] By learning relevant social science theories, URM students in the Academy for Future Science Faculty can better navigate and guide their own success.

Throughout the duration of the study we will be collecting a wide array of qualitative and outcome data to determine the impact of the Academy. Since the ultimate outcome of an academic career is many years away, we will measure successful progression through graduate school as early indictors (e.g. – numbers who drop out of the PhD, successful passing of qualifying exams, challenges at identifying dissertation labs, abstract and paper

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submissions, etc.). Annual interviews and surveys will also acquire extensive data on career thinking and continued interest in academic careers, perceptions of the achievability of academic careers, etc.

CONCLUSION

Development of untapped talent within underrepresented and disadvantaged students who are interested in careers in biomedical research is more important than ever because of demographic trends, research manpower trends, evidence that research teams gain problem-solving capacity by diversification and that increases in participation of URMs in biomedicine is expected to invigorate efforts directed at health and health care disparities among their constituent groups. Achievement of a more rapid pace of growth in participation by these students will require continued innovation in interventions of many kinds and at many points in the 'pipeline.' The interventions, if well-grounded and tested for efficacy, should have broad applicability to increasing the quality of training and early career experiences for all young scientists.

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