Inspiring and Ethical Mentorship in STEM: A Meeting Highlighting Need for Engagement, Incentives, and Accountability

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Abstract

Academic research institutes have a responsibility to train the next generation of scientists in safe, inclusive environments. However, recent data has shown an increasingly worrying trend of early career researchers (ECRs), particularly underrepresented minorities (URMs), struggling to gain academic independence in STEM fields. While hypercompetition, lack of research funds, and scarce independent research opportunities are systemic sources of this problem, research shows that inadequate mentoring and toxic cultures are major contributors to attrition rates. To address the state of mentoring in STEM, and to discuss further actions to take to improve STEM mentoring, early-career researchers organized a meeting at UMD-College Park on academic mentoring. The talks and workshops, which included students, postdocs, and experts in both STEM and mentoring fields, focused on culturally aware mentoring, hypercompetition, mental health, ethical behavior, and advocacy. Here, we provide an overview of the mentoring landscape experienced by ECRs and describe available resources and further actions for the academic community to join with to improve mentoring practices.

Introduction

Academic research institutes have a fundamental responsibility towards their trainees which includes teaching technical proficiency in research and career development in a safe and

inclusive environment. It is critical to the development of a productive environment for training, particularly in an apprentice-like model such as employed in academe, that those who we call "mentors" are providing competent and appropriate mentoring to allow the next generation to succeed. Yet what good mentoring looks like, and whether good mentoring is being practiced in research training environments, is an area of active discussion (National Academies of Sciences 2017), not least among the community of early career researchers, largely on the receiving end of mentoring.

Part of the basic measure of success in mentoring is whether successive generations are able to succeed in STEM, and particularly in academe. Recent data indicates that the science and engineering workforce has been aging at a higher rate than the general workforce (Blau and Weinberg 2017), even though the populations of graduate students and postdoctoral researchers have been steadily increasing (Kahn and Ginther 2017). Despite increases in the number of graduates holding advanced degrees in STEM fields, particularly those from underrepresented minority (URMs) backgrounds, few are obtaining independent research positions in universities and research institutions across the nation, with the transition from postdoctoral to faculty positions proving a major bottleneck to achieving a diverse faculty (Ginther et al. 2011; Gibbs et al. 2016; Meyers et al. 2018).

Beyond lack of independent research opportunities and scarce research funding, one reason for this attrition is the current state of mentoring. In addition to a lack of institutional evaluation of current mentoring practices, and the few systemic incentives to mentor well (compared to publishing papers and successfully applying for grant awards), there is a high prevalence of sexual harassment (Ghorayshi 2016; Wadman 2017), second only in prevalence to the military (National Academies of Science, 2018) and other types of harassment and bullying of scientists in academia (Poole 2016; Payne 2017), which are rarely held accountable by institutions (Kinkade 2017). In these cases, mentors and working conditions in institutions are not just passively failing to provide trainees with adequate support, but are actively contributing to their decision to leave academia (Poole 2016). Indeed, a study that found a high rate of mental health problems in PhD students reported that mentorship style and workplace environment were among the highest predictors of risk for depression (Levecque et al. 2017).

Strong, positive mentorship has been demonstrated to have the opposite effect. Studies on the effects of mentorship relationships on science trainees, recently reviewed by Beech *et al.* and Pfund *et al.* (Beech et al. 2013; Pfund et al. 2016), have shown that "strong mentorship has been linked to enhanced mentee productivity, self-efficacy, and career satisfaction [and is] an important predictor of the success of researchers in training" (Pfund et al. 2016). Despite this, women (Watt et al. 2005) and URM (Beech et al. 2013) mentees self-report lower levels of

mentoring and mentoring satisfaction than their white and asian male counterparts. This leads to lower levels of representation and support for these groups within academia.

Some efforts are already in place to both study and address these issues. The National Science Foundation recently updated their harassment policies (https://www.nsf.gov/od/odi/harassment.jsp), stating that the "NSF expects all awardee organizations to establish and maintain clear and unambiguous standards of behavior to ensure harassment-free workplaces wherever science is conducted, including notification pathways for all personnel." Another resource, the National Research Mentoring Network (NRMN), currently provides access to remote mentoring for graduate students in STEM, and runs training and workshops for mentors interested in expanding their mentoring proficiency.

Last year, the National Academies of Science, Engineering and Medicine (NASEM) also held a two-day workshop to explore how "the complex and dynamic [mentoring] relationships form, evolve, and impact the lives and careers of the current and next generation of STEMM [Science, Technology, Engineering, Medicine and Mathematics] professionals." (National Academies of Sciences 2017). A study on mentoring is currently underway at the NASEM. Indeed, three recent reports from the NASEM have either directly or indirectly called out problems with the state of mentoring in enabling successive generations, and the next generation of researchers, to succeed (Committee on the Next Generation Initiative et al. 2018; Committee on the Impacts of Sexual Harassment in Academic Science, Engineering, and Medicine et al. 2018; Committee on Revitalizing Graduate STEM Education for the 21st Century et al. 2018).

Organizing the Inspiring and Ethical Mentorship in STEM Meeting

Because of the important role that mentoring plays in the professional development of ECRs, and to identify ways to make change to the current system, Future of Research (FoR) in collaboration with the University of Maryland (UMD) College Park, held a symposium entitled, "Ethical and Inspiring Mentorship in STEM."

Future of Research (FoR, http://futureofresearch.org) is a nonprofit organization that wants to champion, engage and empower early career researchers by providing them with evidence-based resources to improve the research enterprise.

The meeting was held at University of Maryland (UMD) College Park on September 21st, 2017, during National Postdoctoral Appreciation Week. UMD College Park has a number of faculty who are leaders in the National Research Mentoring Network (NRMN), and an active Office of Postdoctoral Affairs that helped with organizing the meeting. The meeting was advertised and open for registration to graduate students, postdocs, and faculty alike.

The goals of the meeting were to:

1. Recognize and discuss issues surrounding mentoring in STEM fields.
2. Discuss effective mentoring and advocacy techniques for graduate students, postdocs, staff researchers, and faculty.
3. Provide a forum to connect like-minded Early Career Researchers (ECRs) who wish to effect change at their institutions through grassroots efforts.
4. Inspire participants to practice effective mentorship while promoting these skill sets to their peers and colleagues.

The "Inspiring and Ethical Mentorship in STEM" Meeting

Initial Discussions:

To frame initial discussions and explore STEM researchers' opinions, thoughts, and collect resources on the topic of mentoring in STEM fields, a Twitter chat was held by Future of Research and the Union of Concerned Scientists (UCS, https://www.ucsusa.org/) a week prior to the meeting, including various stakeholders with the mission to improve mentoring (the National Research Mentoring Network (NRMN, https://nrmnet.net/), Addgene (https://blog.addgene.org/topic/mentoring-for-scientists), SACNAS (the Society for Advancement of Chicanos and Native American Scientists, http://sacnas.org/) and Future PI Slack, https://futurepislack.wordpress.com/). Key ideas emerging from these discussions are summarized in Figure 1.

Meeting format

On the day of the meeting, opening remarks framed the overall discussion regarding the importance of mentoring in STEM fields. The meeting consisted of three talks, four workshops, and a panel discussion designed to engage attendees in conversations about different aspects of mentoring, and to receive feedback and ideas from attendees regarding these topics. Table 1 shows the schedule of the meeting, along with details on the talks and workshop facilitators.

Due to the sensitive, confidential nature of the topics covered during the mental health workshop, gendered pronouns and other identifying information in comments from participants have been removed.

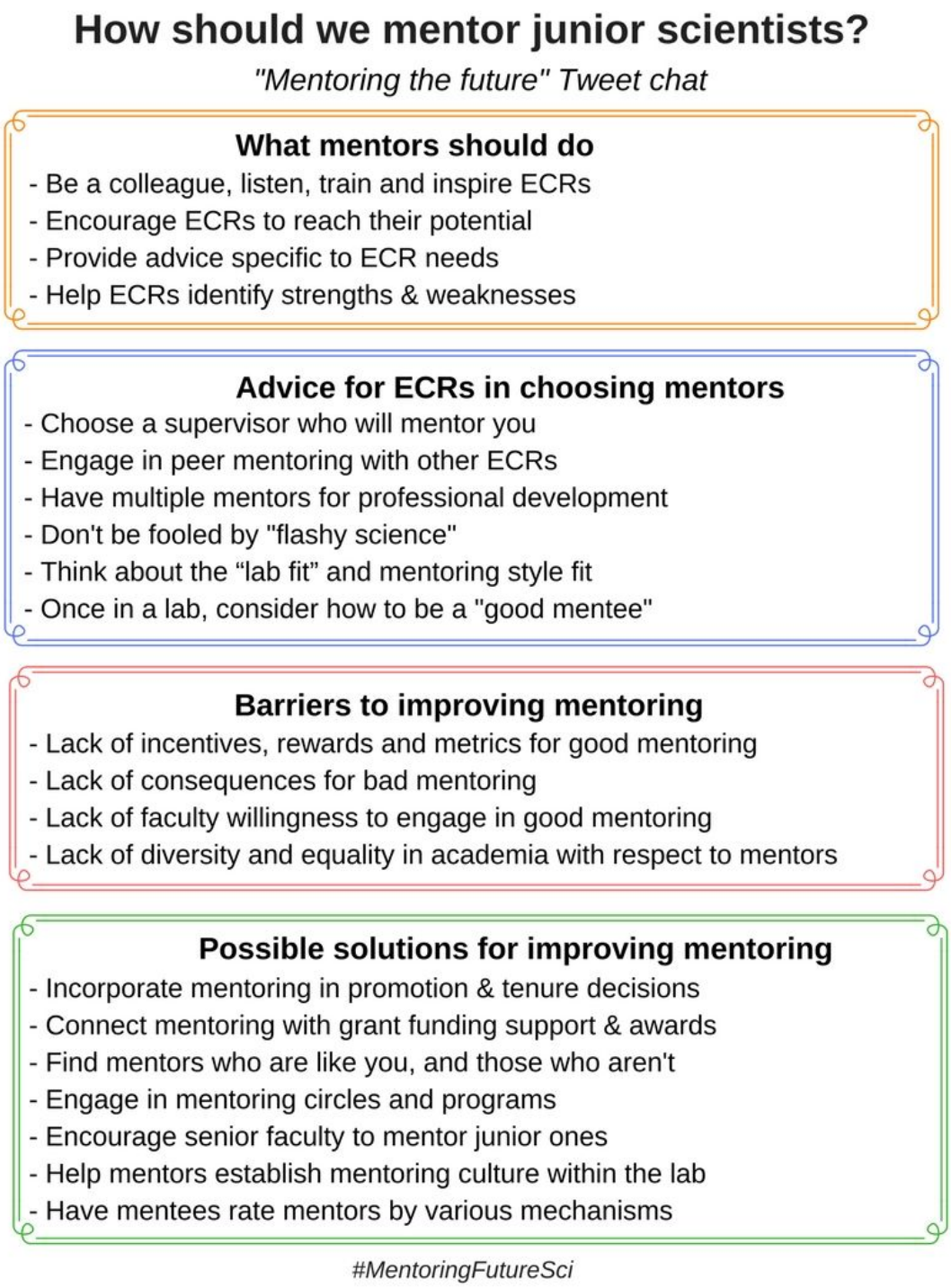

Figure 1. Summary of results from the #MentoringFutureSci Twitter chat. The Twitter chat prior to the meeting aimed to define broadly the concept of mentoring from various stakeholders, as well as provide ideas for what ECRs should consider when choosing mentors. In addition, the chat highlighted numerous barriers and possible solutions to improving mentoring, including how to incentivize and reward this practice in academia.

Workshop/Talk/Panel	Facilitators/Speakers
Keynote Address: Mentoring Networks	Dr. Sandra Quinn (UMD, NRMN)
Talk: Training vs. Labor	Dr. Chris Pickett (Rescuing Biomedical Research)
Talk: Ethical Leadership	Brooke Deterline (Courageous Leadership, LLC)
Workshop: Culturally Aware Mentoring	Dr. Sandra Quinn (UMD, NRMN)
Workshop: Local Advocacy - Tools for Change	Dr. Gary McDowell (Future of Research) Amy Gutierrez (UCS) Anisha Mehta (UCS)
Workshop: Mentoring Across the Industry/Academia Divide	Dr. Will Olds (Proteintech)
Workshop: Mental Health, Support Networks, and Difficult Conversations	Juan Pablo Ruiz (Future of Research)
Panel Discussion: Moving Forward for Mentoring	Dr. Belinda Lee Huang (Celadon Leadership Consulting) Dr. Meg Bentley (American University) Dr. Andres De Los Reyes (UMD) Dr. Chinonye Nnakwe (AAAS; I-Corps™)

Table 1: Meeting components and facilitators.

Talks: Mentoring Networks, Training vs Labor, and Ethical Leadership

The conference hosted three talks from speakers with an interest in improving mentoring: Dr. Sandra Quinn from the University of Maryland College Park, and part of the leadership team of the National Research Mentoring Network's (NMRN, www.nrmnet.net) mentor training core; Dr. Chris Pickett, Director of Rescuing Biomedical Research (RBR, http://rescuingbiomedicalresearch.org/); and Brooke Deterline, partner and CEO of Courageous Leadership, LLC (http://www.thecourage2lead.com/).

Dr. Sandra Quinn is a leader of the mentor training core at NRMN, "a nationwide consortium of biomedical professionals and institutions collaborating to provide all trainees across the biomedical, behavioral, clinical and social sciences with evidence-based mentorship and professional development programming". Dr. Quinn presented data on the importance of mentoring in the development of early career researchers (ECRs, Figure 2). Extensive research has shown that providing strong mentorship for STEM ECRs and undergraduate students leads to enhanced science identity, belonging, and self-efficacy (Feldman et al. 2010; Cho et al. 2011; Chemers et al. 2011), as well as persistence (Sambunjak et al. 2010; Bordes-Edgar et al. 2011), research productivity (Steiner et al. 2002; Wingard et al. 2004), career satisfaction (Beech et al. 2013), and higher URM recruitment (Hathaway 2002). She also elucidated the role that race and cultural background play in creating successful mentor/mentee relationships, a topic she spoke about in much more detail during her subsequent workshop entitled, "Culturally Aware Mentoring," described in the following section.

Dr. Chris Pickett is the Director of Rescuing Biomedical Research (RBR, http://rescuingbiomedicalresearch.org/), a non-profit organization aiming to "catalyze changes that promote effective science policies and culture in the biomedical research enterprise". Dr. Pickett presented data during his talk to highlight the level of hypercompetition in the biomedical research enterprise, citing how the rise in numbers of biomedical science PhDs has far outpaced available faculty positions (Figure 3). With regards to tenure track positions specifically, Dr. Pickett noted from an analysis of NSF data that those who received a biomedical PhD in 1968 had a greater than 50% chance of being in a tenure track position within five years of degree completion, as compared to a less than 15% chance for those graduating in 2001 (Weissmann 2013). That fact, coupled with the pressure to publish in "high-impact" journals, has only worsened the hypercompetitive nature of the system. Pickett then went on to highlight how this puts pressure on both mentors and mentees, leading to a decrease in the quality of mentorship that trainees receive. The shift from funding PhDs and postdocs on fellowships and training grants to research grants, rather than the repeated proposed recommendation to shift financial support in the other direction (see Section 1.4, (Hussain and Field 2017)), has led to PhDs and postdocs becoming viewed as cheap labor rather than "trainees", compounding on a lack of prioritization for mentoring these groups. It is important to note that the latest NASEM report,

titled “Breaking Through,” calls for a shift from supporting postdocs on research awards (R mechanisms) to training grants (F and K awards), in agreement with previous reports (Committee on the Next Generation Initiative et al. 2018). Likewise, the NSF currently requires all grants supporting postdocs to include a supplementary document detailing the researchers’ mentoring plan (https://www.nsf.gov/bfa/dias/policy/factsheets/por_mentor.pdf).

Brooke Deterline, from Courageous Leadership, gave her talk on “The Science of Ethical Leadership.” Deterline has worked with clients in the equally high-pressure environments of Wall Street and nonprofit organizations. She pointed to data as well as personal anecdotes to show how high-pressure and hypercompetitive environments foster unethical decisions at the leadership level as well as a learned helplessness”, the feeling of powerlessness to drive effective change (Abramson et al. 1978), among those within the group who notice this behavior but are afraid of speaking out. More importantly though, she showed that people can be trained using Social Fitness™ training (http://www.shyness.com/social-fitness-training/social-fitness-training-program/) to not only avoid making these unethical decisions, but to speak out when they occur. Social Fitness™ training was a modality originally developed by psychologist Dr. Lynne Henderson to help patients overcome shyness and social anxiety through role-playing, but has since been used by Deterline and others to safely simulate high-stress level situations and allow people to become used to acting ethically in the face of adversity and threat. Change is more likely to come about, and repercussions to the individual speaking out diminished, Deterline also remarked, when speaking out in groups of three or more, highlighting the need for a good support network (Figure 4).

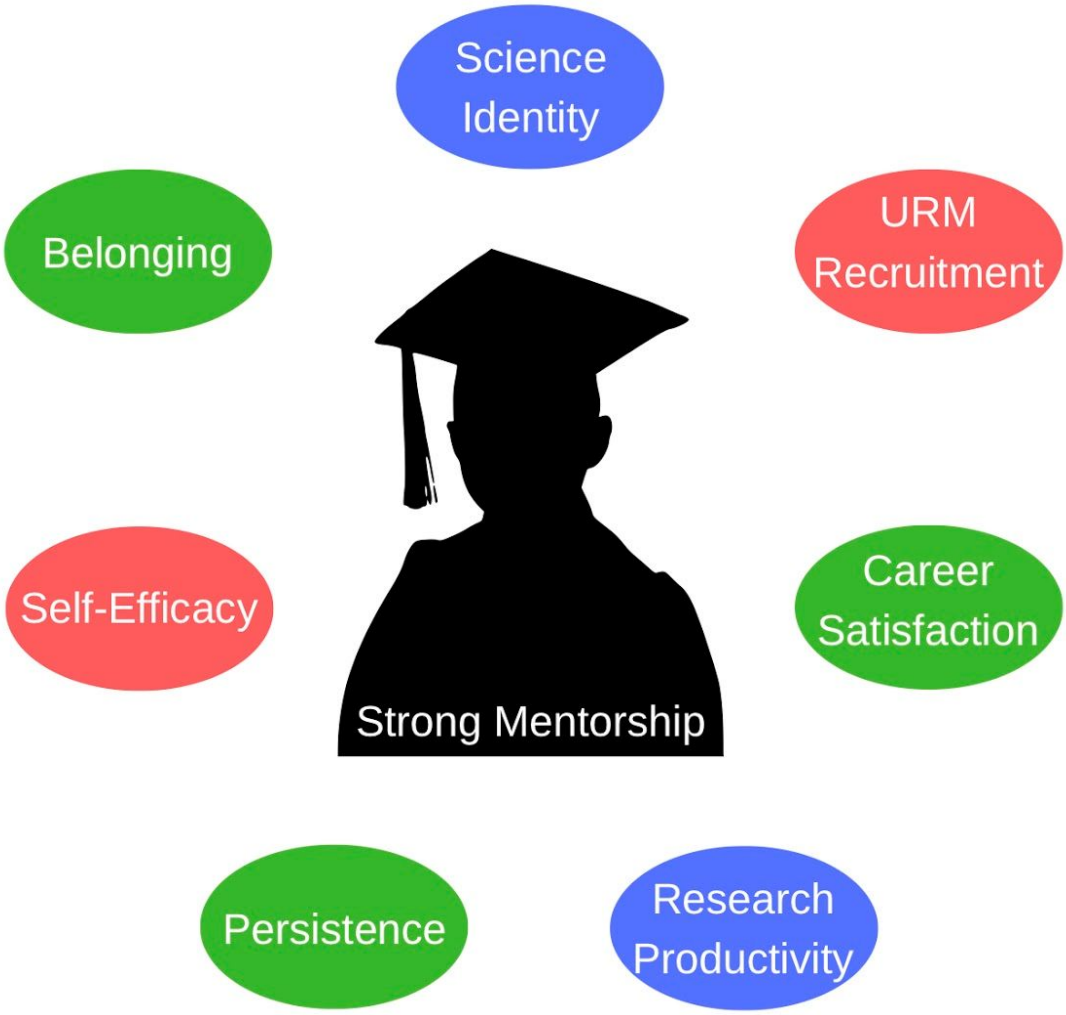

Figure 2. The importance of strong mentoring, adapted from Dr. Quinn's talk. Strong mentorship for STEM trainees leads to an enhanced sense of science identity, belonging, and self-efficacy. It also leads to higher levels of persistence, research productivity, career satisfaction, and recruitment of URM trainees.

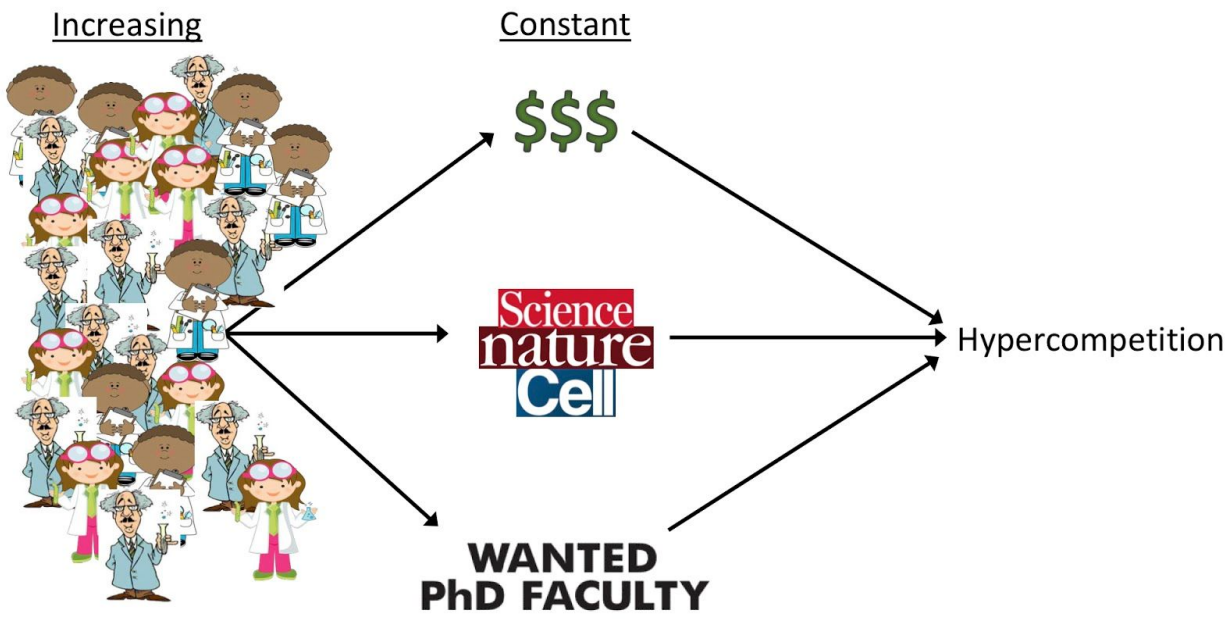

Figure 3. Slide from Dr. Pickett's talk on the state of hypercompetition. Increasing numbers of scientists with advanced degrees competing for limited funds, "high-impact" publications, and tenure track positions have led to the current state of hypercompetition.

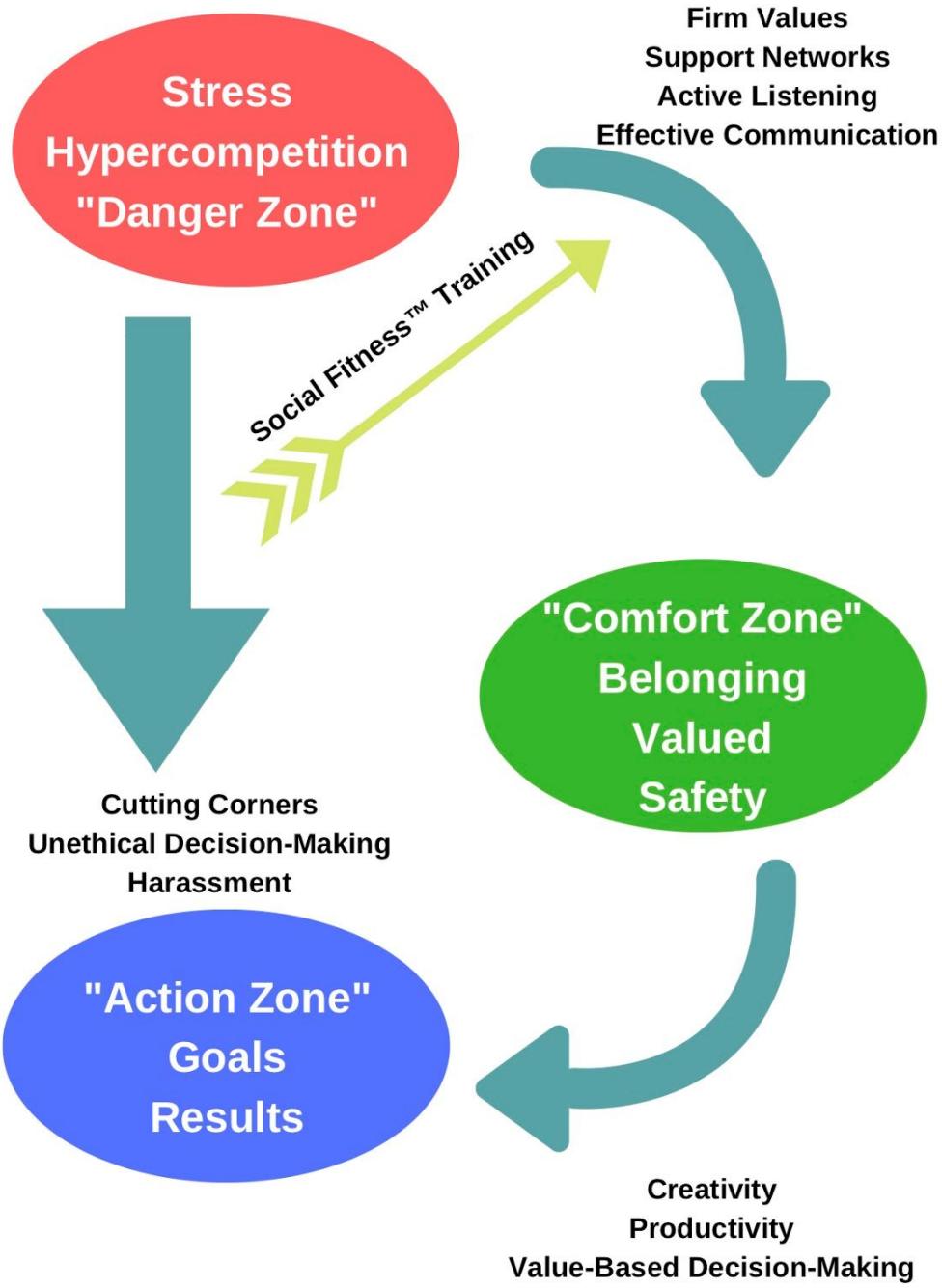

Figure 4. Summary of Deterline's talk on consequences of hypercompetition and stress. Making decisions towards goals and results while in the "Danger Zone" of hypercompetition and stress leads to cutting corners and unethical decision-making. On the other hand, if teams have firm values, a strong support culture, and communicate effectively, stress is effectively dealt with, leading to the "comfort zone," of feeling valued and a sense of belonging. From here, decisions are made based on a group's values and lead to higher creativity and productivity. Deterline's company runs Social Fitness™ workshops to train leaders to more effectively and ethically respond to stressful situations.

Insights from Participatory Workshops

Culturally Aware Mentoring (#1)

Dr. Sandra Quinn delved deeper into themes introduced during her keynote talk and focused on her research and recommendations for culturally aware mentoring. Additional information on culturally aware mentoring can be found at the University of Maryland School of Public Health's Center for Health Equity (http://sph.umd.edu/center/che/news-item/mentor-training-improve-diversity-science). During the session, Quinn pointed out that, in order to be an effective mentor, one must be aware of the culture and background of "mentees". She brought up several examples of how the same mentoring style may not be effective for all mentees, and that mentors may have to adapt their style to best suit the culture and background of their mentees.

One example included a mentor with two mentees: one of the same race and gender as the mentor (mentee #1), and one of a different racial background than the mentor (mentee #2). While both mentees entered the lab with the exact same academic qualifications, in this example, the two mentees demonstrated quite different success rates as time progressed. Despite the mentor allotting equal time and using the same mentoring style, mentee #1 thrived, while mentee #2 struggled with results and fitting into the lab. Quinn used this example to demonstrate that the same mentoring style may not work for all trainees, and that mentors must take into account their mentees' backgrounds in considering appropriate and effective mentorship.

So, how does one become a culturally aware mentor? Quinn recommends starting the conversation by showing respect for and being available to mentees: by being available, mentees from all backgrounds may feel more at ease approaching the mentor and seeking guidance. In addition, it is important to validate your mentees' experiences: how one individual experiences an event may differ greatly from another, based on a number of factors including background, socioeconomic status, and gender.

By validating the mentee's feelings in regards to an experience, as a mentor, you signal that you accept how they felt, even if you may not agree with the conclusions or may have experienced the same situation differently. This provides a foundation to establish a thriving mentor/mentee relationship, and allows the mentee to gain trust in the mentor.

Finally, Quinn brought up the subject of "Imposter Syndrome"- a common occurrence in academia where faculty and trainees feel as though they are not as professionally competent as others may perceive (Langford and Clance 1993; McGee 2017; Laursen 2008). Imposter syndrome can stunt progress of otherwise well-qualified researchers and cause them additional stress and anxiety. Quinn explains that using one's own experience to guide another person through their experience can help quell feelings of insufficiency and foster intellectual growth

and development. As a mentor who has shown success in their field, expressing and discussing your own insecurities or self-doubt throughout your training can serve as an example for trainees who may be struggling with similar issues. By providing a relatable experience and demonstrating effective mechanisms to overcome imposter syndrome, mentors help generate a sense of security and acceptance for their mentees.

After these guidelines and recommendations, Quinn provided some astonishing facts supported by studies demonstrating disparities in hiring practices and leadership in academia. Studies show that many science faculty rate male applicants as more competent than female applicants, and offer males higher salaries (Moss-Racusin et al. 2012). Furthermore, additional studies show that male biologists at elite institutions are less likely to hire or train women in their labs (Sheltzer and Smith 2014), and that white mentors tend to have "colorblind" attitudes when mentoring students of color (McCoy et al. 2015). Importantly, Quinn said that conversations about why we lack diversity in academia, barriers encountered and race/ethnicity issues are often left to minority researchers to address instead of being a concern to the entire academic enterprise. This leads to an increased burden of service on white women and minority faculty (Guarino and Borden 2017; Rodríguez et al. 2015). Faculty of all backgrounds, not just minorities, should take an active role in these conversations.

One potential explanation for this phenomenon is that advisors or mentors often feel uncomfortable addressing diversity issues if they themselves are not minority scientists. However, URM mentees often appreciate when their mentors bring up issues of diversity (Muller et al. 2012). Quinn recommends beginning this conversation by addressing the "elephant in the room" and acknowledging the mentee's unique background, and then offering to learn about how their race/ethnicity, or upbringing, may influence their academic experience.

Quinn concluded the session by pointing out a current disconnect revolving around culturally aware mentoring. Do race and ethnicity matter in determining one's ability to do science? The answer is actually yes. That is not to say a scientist from a specific background or race is any more or less capable of doing science, but that awareness and understanding of one's background, race/ethnicity, and potential barriers are necessary in order to mentor them effectively and ensure the mentee is best prepared to move forward in their professional development.

Local Advocacy - Tools for Change (#2)

This workshop was designed to provide attendees with tools to bring about change, within their own institutes and at local and government levels.

During the first half of the workshop, Amy Gutierrez and Anisha Mehta, from the Union of Concerned Scientists (UCS), spoke to attendees regarding the importance of advocating at different levels of government for science and evidence-based policy decisions. Through their Science Network (https://www.ucsusa.org/science-network), UCS mentors and connects scientists to policy makers and enables communication and advocacy on topics that are important to society, which PhD students and postdocs have expertise in (see The Science Network Mentor Program, http://bit.ly/2s61MH0).

During the second half of the workshop, Dr. Gary McDowell from Future of Research (FoR) engaged attendees in a sticky note activity resulting in a list of barriers and problems (Table 2) to receiving appropriate mentoring, followed by a list of potential solutions and actions (Table 3; see (McDowell et al. 2014) for workshop methodology). Both lists of responses were then grouped into five major arising themes:

- *Lack of Communication/Knowledge;*
- *Lack of Representation/Shared Governance;*
- *Lack of Incentives/Accountability;*
- *Lack of Diversity in Potential Role Models;* and
- *Professional Stress/Pressure*.

Of these, the most common themes for barriers fell under the *Lack of Communication/Knowledge* and *Lack of Incentives/Accountability* categories. Despite resources available for learning how to mentor or improve mentorship skills, workshop participants pointed to a lack of knowledge or awareness of these resources both as mentors and mentees. When knowledge of the resources is available, another barrier seems to be a lack of systemic and cultural incentives to mentor effectively, and a lack of accountability for bad and even toxic mentoring.

The list of solutions provided by participants contained a majority of solutions aimed toward this second barrier of *Lack of Incentives/Accountability*. Sample responses are provided in Table 3. A full list of responses can be found in Supplementary Table 1.

Category	Sample Responses	Count
Lack of Communication/Knowledge	"No training in mentoring" "Not sure what to look for in a mentor" "Fear of saying you don't know/understand something as a mentee"	13
Lack of Representation/Shared Governance	"Need for a postdoc association" "Postdoc recognition" "Department has no listserv for postdocs"	6
Lack of Incentives/Accountability	"Mentorship isn't rewarded (formally)" "Lack of accountability for mentors" "My mentor doesn't care"	11
Lack of Diversity in Potential Role Models	"Mentor bias" "Not having senior women/minorities in the field" "Difficulty finding mentors outside academia"	7
Professional Stress/Pressure	"Time" "Hypercompetition" "Unforgiving academic pipeline"	9
Total		46

Table 2. Problems and Barriers towards Effective Mentoring.

Category	Sample Responses	Count
Lack of Communication/Knowledge	"Having conversations/meetings like these (awareness)"	1
Lack of Representation/Shared Governance	"Treat postdocs as employees of the institution and not just of individual labs"	1
Lack of Incentives/Accountability	"Training mandatory for new faculty for mentoring and leadership" "Dept takes responsibility of fostering supportive culture" "Consequences for abusive mentors"	10
Lack of Diversity in Potential Role Models Diversity	"Sympathetic PI who supports your lab decisions" "Broaden mentoring network/seek mentors in different places"	2
Professional Stress/Pressure	"Hierarchy of mentorship (helps with time constraints)" "Change the structure of academic mentoring - add a role for staff scientists (who are more available usually) as a co-mentor"	2
Total		16

Table 3. Solutions for Problems in Effective Mentoring.

Mental Health, Support Networks, and Difficult Conversations (#3)

For some time, it has been known that mental health and well-being in the workplace affect the productivity of employees across various sectors (Danna and Griffin 1999). Likewise, data has shown that stress can impair learning, and lead to shifts from a "flexible, 'cognitive' form of learning towards rather rigid, 'habit'-like behaviour" (Vogel and Schwabe 2016).

In 2014, the graduate student assembly at Berkeley published a study in which they found that 43% - 46% of graduate students in STEM fields scored as being depressed (The Graduate Assembly 2014). Three years later, a study of a representative population of PhD students in Flanders, Belgium, found that one in two students experiences psychological distress, while one in three is at risk of a common psychiatric disorder (Levecque et al. 2017), and these numbers are significantly higher among PhD students than among a similarly highly-educated non-graduate student population.

When presented with this data, one workshop participant mentioned that, although the prevalence of mental health issues among PhD students in these studies was high, they were not surprised by this fact, and suspected this may be higher in some places, and heavily dependent on the institute, as well as the culture and mentoring support. Indeed, both of these studies showed that mentoring and advising styles were predictors of students' mental health, with one student in the Berkeley study claiming:

"My adviser is not useful as a mentor and doesn't really help much with my project, but that is typical for advisers and if you expect otherwise, you didn't have realistic expectations for graduate school" (The Graduate Assembly 2014).

One workshop participant then mentioned suicide, and the devastation it can cause on team members in the lab, particularly those who find themselves under the same stressful conditions. While there is also a lack of data in STEM surrounding suicides arising from mental health issues in academia, a paper recently published by physicist Oliver Rosten includes the following dedication to a colleague in the acknowledgments section:

"*I am firmly of the conviction that the psychological brutality of the post-doctoral system played a strong underlying role in Francis' death. I would like to take this opportunity, should anyone be listening, to urge those within academia in roles of leadership to do far more to protect members of the community suffering from mental health problems, particularly during the most vulnerable stages of their careers*" (Rosten 2017).

During the workshop, participants suggested that data on student well-being and mental health should not only be collected more widely across universities, but should also be made available

to incoming graduate students and postdocs. Likewise, no data that we know of exists detailing the mental health of the postdoctoral population at any institute, which is unsurprising given data on this population is largely either non-existent or poorly documented in STEM fields (Committee to Review the State of Postdoctoral Experience in Scientists and Engineers et al. 2014; Pickett et al. 2017).

A recent study held at Google (Duhigg 2016) found that the largest predictor of their most productive and creative teams was the team members' comfort with expressing both personal and professional concerns and problems to both their team members and leaders.

When asked if they were comfortable approaching and communicating with supervisors regarding mental health or other such concerns, few participants at our workshop answered affirmatively, with those doing so mentioning the positive effect they perceived on their overall well-being and success in the lab following this. One participant with a different experience commented:

"*The relationship with my supervisor is strictly professional. They made it clear to us upon starting that any personal issues have no place in our meetings and discussions.*"

Finally, when participants were presented with learning material on active listening and non-violent communication (www.cnvc.org) for conflict resolution and difficult conversations, none had been previously exposed to such material, although many commented after the brief overview that they felt learning more about such practices would be valuable in both their personal and professional relationships.

Mentorship Across the Industry/Academia Divide (#4)

The careers of biomedical scientists have mostly shifted away from academia. According to a report from the NIH on the biomedical workforce, nearly three out of every four biomedical scientists with PhDs do not obtain tenure-track faculty positions, and those who do are taking more than 5 and up to 20 years post-PhD to do so (Biomedical Research Workforce Working Group 2012). This decline, which has been evident from the 1970s has occurred for a variety of reasons (e.g. wages, job availability, private sector funding, expansion of graduate admissions).

Despite this issue and urging from government funders, the NIH's Biomedical Research Workforce Working Group noted that graduate training and mentorship have focused on the preparation of students for tenure track faculty positions and thus do not provide them with sufficient resources towards career exploration and training for non-academic positions (Biomedical Research Workforce Working Group 2012). This can leave trainees with a lack experience, confidence, and guidance in their post-academic career paths. This issue prompted the creation of a temporary funding opportunity from the NIH Common Fund, the NIH Broadening Experiences in Scientific Training (BEST) programs (Meyers et al. 2016), to support experiments and development of best practices in training graduate students and postdocs for a range of career opportunities. The Mentorship Across the Industry/Academia Divide workshop sought to diagnose the scope of the problem and identify clear paths moving forward and implementable practices for mentors, faculty, and administrators in universities.

Due to the pressure to follow the academic path, students and postdocs often feel uncomfortable broaching the topic of non-academic careers to their mentors. Consequently, the workshop opened with a discussion of how to facilitate this conversation. Participants emphasized the need for university administration to set the tone by requiring discussion of career options in committee meetings and providing resources such as career fairs and talks from alumni in industry.

The discussion then turned to concrete ways in which mentors can help their mentees achieve non-academic career goals. Many participants noted that the most commonly used method, email introductions, is not effective for networking. Since in-person meetings are preferable, one idea was to encourage mentors to host networking retreats featuring their laboratory's alumni and colleagues. One participant also proposed the idea that even if a mentor has few connections to industry, they could offer mentees additional roles and responsibilities in the laboratory to sharpen the skills that would be useful towards their future industry careers.

The workshop next focused on the role of department and university administrators in supporting mentees' career development. Participants noted that the current academic system does not incentivize faculty to help their mentees find jobs outside of academia. One proposed solution

was to include incentives for faculty promotion based on the career outcomes of their students. This practice would align the interests of mentors and mentees, likely fostering a stronger collaboration towards achieving the mentees' career goals. Another participant noted that university administration could also honor mentors who excel in helping students find non-academic jobs. This accolade would both elevate the cultural status of non-academic career outcomes and incentivize mentors to support mentees' development outside of academia.

Participants emphasized the need for university administration to take advantage of outside resources. At the moment, alumni are an untapped resource in many departments and programs. Providing more funding towards tracking alumni and connecting them to graduate students while in their PhD training would be a great start to addressing this issue.

Additionally, participants recommended that universities establish relationships with firms to create internships and shadowing programs for their PhD students. However, implementation of such programs remains a challenge and might not be welcomed by academic supervisors since they would divert time away from the laboratory. In addition, university administrations would have to consider addressing issues such as healthcare coverage and stipends during internships for students.

Discussion of these issues is a worthwhile first step towards change, but the key is the establishment and maintenance of strong relationships between stakeholders. Proposals by workshop participants in terms of actionable items for different stakeholders are summarized in Table 4. Participants lamented the lack of power that students have in the academic hierarchy to make systemic changes. However, student advocacy efforts, such as petitions and affinity groups were cited as an effective way to start such a dialogue. One participant recommended scheduling regular departmental town halls to discuss these issues. Nothing is a "magic" fix. Significant improvement in this area will require years of effort and advocacy, but it is necessary to improve career development for students and postdocs.

Stakeholder	Proposals
Principal Investigator/Mentor	• Require discussion of mentee's career goals during performance reviews • Organize alumni retreats to allow former and current mentees network in-person • Provide opportunities in the laboratory for mentees to sharpen skills needed down the road
University Administration	• Organize career fairs and talks to support exploration • Tie faculty promotion to career outcomes both inside and outside of academia • Honor mentors who excel at placing mentees in non-academic positions • Track careers of university alumni • Establish relationships with firms for internships and recruitment
Mentees	• Form career development clubs • Engage in student advocacy to promote student-centric policies

Table 4. Proposals for Supporting Transitions to Industry and Non-academic Positions.

Moving forward for Mentoring: A Panel Discussion

To wrap up the symposium and workshop, panelists from various institutions and career levels provided valuable insights during an interactive session. The panelists comprised Dr. Belinda Lee Huang, Principal of Celadon Leadership Consulting; Dr. Meg Bentley, Director in Residence of Laboratories in the Department of Biology at American University; Dr. Andres De Los Reyes, Associate Professor of Psychology at the University of Maryland; and Dr. Chinonye Nnakwe, formerly of AAAS and currently developing interventions to cultivate a National Innovation Network of I-Corps™ Mentors.

At the start of the panel, participants provided many resources they had used in their own training to become effective mentors. Recommendations included: *How to Write a Lot*, by Paul Silva (Silvia 2007) *Houston We Have a Narrative*, by Randy Olson (Olson 2015); and *Designing your Life*, by Bill Burnett (Burnett and Evans 2016) as well as the podcast, Manager Tools (https://www.manager-tools.com/all-podcasts). The panelists suggested that reading across disciplines, for example, books on management in business, can provide valuable insights that are applicable to running a lab and mentoring trainees in an academic setting.

As an early step in becoming an effective mentor, the panelists suggested writing or developing a mentoring philosophy. This can be done by emulating qualities observed in effective mentors and by researching philosophies from others to fine tune one's own interests. To become an effective mentor, the panelists recommended being consistent with communication. This allows for the mentor and mentee to set up realistic goals and expectations for their training.

Additionally, the panelists recommend mentors hold off expectations at the start of a mentoring relationship, as it often takes time to establish what style will work best for the mentor/mentee pair, as well as to determine realistic and desired goals of the mentee. The mentee's goals may differ from the mentors (e.g. a mentor may want the mentee to go into academia, but the mentee may desire a career in industry), thus open communication is critical to ensuring that both parties are aware of the common interests and utilize the most effective mechanisms to reach these goals.

General qualities of an effective mentor include empathy, engagement, and being observant of trainees. Finally, panelists encourage rewarding success in trainees, even if it is small. This establishes a positive atmosphere and motivates productivity, whereas coercion tactics are far less effective in both establishing good mentor/mentee relationships and overall training success.

The panelists also provided recommendations for finding high quality mentors. The overwhelming suggestion from all panelists was to seek more than one mentor, as well as a diversity of mentors. Finding a mentor who had similar experiences to you as a trainee is

valuable. However, it is also important to seek mentors with different experiences or career paths, and who can help elevate your status. For example, if you are in academia and want to switch to industry, seeking out a CEO or chair of a big industry company and asking for an informational interview would be a good start.

Importantly, the panel suggested writing out a list of behaviors or qualities you want or need from a mentor, such as: a hands-on or hands-off management style, someone who quickly responds to emails, but also someone with other distinguishing traits such as having a family, being able to encourage work-life balance, etc. By writing down these behaviors, it will help you fine tune what you seek in a mentor, but also help you communicate how to draw out these qualities from the mentor.

Another important aspect of being a mentee is the ability to "mentor up" (Lee et al. 2015), or to bring out desired qualities or actions from your mentor. Panelists agree that as a mentee, it is a good idea to explain what you need from a mentor - for example,communicating to your mentor that you would like to have weekly check-ins to assess progress. Finally, by determining the qualities you wish to see in your mentor and by effectively mentoring up, this can help you develop and formulate your own mentoring philosophy.

Conclusions and Discussion

It is clear from previous studies that mentoring plays an important role in the professional development of STEM trainees (Pfund et al. 2016). Effective mentoring practices can have a positive effect on students' mental health (Levecque et al. 2017), and have been tied to a more enjoyable training experience and higher academic success (Scaffidi and Berman 2011). A large body of work, resources, and training practices to improve mentoring is already available. One important resource is an effective training methodology published by NRMN a few years ago, which was shown to increase mentor competence (Pfund et al. 2014), and continues to be developed to add research and improve on current practices.

Despite this, continued gaps to fill this mentoring need exist, particularly for women and URM trainee populations in STEM (Beech et al. 2013). The need for and importance of effective mentoring have also been recognized in other conferences as major themes relevant to the future of the biomedical research enterprise (Hitchcock et al. 2017). In agreement with other publications and discussions surrounding this topic, our meeting workshops found that issues and barriers to effective mentoring arise from two main sources:

1) Lack of knowledge, training, and communication about effective mentoring.
2) Lack of incentives for effective mentoring behaviors and a lack of accountability for negligent and/or toxic mentoring behaviors.

These two issues, however, are not unrelated. The lack of systemic and institutional incentives for effective mentoring practices leads to low levels of interest in training students and postdocs, and in learning how to mentor, particularly in hypercompetitive environments that reward publication in high impact journals as the main measure for scientific success (See Figure 3). This leads to the current gap between the knowledge available on mentoring best practices and exposure to, and acceptance and implementation of, said knowledge. Hypercompetitive systems and cultures are also at higher risks for egregious and unethical behavior (see Figure 4). Without appropriate and transparent accountability measures in place, egregious behaviors will continue, and only exacerbate hypercompetitive cultural attitudes.

Stakeholders such as NRMN, SACNAS, and Addgene, among others, currently work to increase the knowledge and implementation of mentoring practices as well as diverse representation for leaders in STEM. However, true systemic changes will not come about until institutions and funding agencies modify the incentives for effective mentoring, and implement transparent and effective accountability practices for egregious behaviors. Other conferences have also come to the same conclusions, collectively calling for a "need for funding agencies to advocate for accountability for effective mentoring" (Hitchcock et al. 2017).

The National Science Foundation (NSF) has responded to such calls and requires that for each proposal that requests funding to support postdoctoral researchers, a supplementary document must be included that describes the mentoring plan for the researcher (Anon n.d.). In addition, the NSF recently updated their policy to a clear and specific no tolerance policy for harassment at any NSF-funded institutes or sites (https://www.nsf.gov/od/odi/harassment.jsp). Their updates also included specific avenues for individuals to report harassment, sexual or otherwise. While it is unclear how effectively these policies will be implemented and lead to effective change across institutes, we encourage and challenge other funding agencies, professional societies, and institutes to act similarly. Our call to action for stakeholders to address the two barriers to effective mentoring as discussed above can be seen in Figure 5.

As Figure 5 shows, there is some overlap in the steps that funding agencies, professional societies, and institutes can take in order to bring about the systemic and cultural change that is needed to address all three barriers. Mainly, agencies, societies, and institutes will have to commit to increasing the requirements for exposure to and training in effective mentoring practices for trainees and group leaders. Likewise, they will have to prove their commitment to improving mentoring by both monetarily incentivizing good mentoring practices while holding those who practice toxic or negligent mentoring fairly and transparently accountable. Collaboration and commitment by these levels of stakeholders, as well as by supervisors and trainees will be key in these endeavors.

But calling for change will not be enough, as has been identified with regard to three recent reports from the NASEM (Committee on the Impacts of Sexual Harassment in Academic Science, Engineering, and Medicine et al. 2018; Committee on Revitalizing Graduate STEM Education for the 21st Century et al. 2018; Committee on the Next Generation Initiative et al. 2018). Overhanging all reports was the issue that these reports are part of a succession of recommendations that are often made, but rarely implemented. This is because such reports rely on stakeholders taking up recommendations and enacting them, without the acknowledgment that such changes may require further pressure to enact them, particularly if they go against the stakeholder's immediate interests. This was identified most particularly by the Graduate Education report, which called for graduate students to use this as an advocacy document for grassroots efforts to reform the system. We too believe that grassroots efforts, driven by early career researchers but involving those from all stakeholder groups, will be what is required to change this system, and to ensure that appropriate training for, and recognition of, mentoring in STEM takes place.

Conclusions and Discussion

There were many resources and conversations relevant to the topic of mentoring in STEM fields that made this conference and publication possible. We are grateful to all who contributed and participated. Additional resources of interest can be found in Supplementary Table 2. The resources have been organized and categorized into: general resources to improve academia; general mentoring resources; resources on different types of mentors; and resources on different ways to mentor. The resources presented in this table can thus be utilized towards discussions and effecting change in academia in general, as well as more specific areas including how to train scientists, how to think about mentoring, types of mentoring to consider, how to find mentors, how to choose good/best fit mentors, and examples of successful mentoring programs.

In response to the needs identified in this and other meetings, Future of Research has proposed the creation of the Mentoring Future Scientists consortium (www.MentoringFutureSci.net). Consortium members will be connected to other stakeholders interested in project collaboration or information sharing regarding actionable change in STEM mentoring, while also providing a wide and diverse range of resources freely available for use. This will facilitate conversation across organizations and institutes, as well as foster collaboration on projects that will require various areas of expertise and approaches. In addition, Future of Research have proposed a third-party method of evaluation of departmental and institutional mentoring standards (http://www.futureofresearch.org/wp-content/uploads/2018/11/Mentoring-Future-Scientists_-Future-of-Research-Evaluation-Proposal.pdf). The proposal entails collecting survey data from mentees within a department, and requiring departments and institutions to submit evidence to qualify for badges. The system is similar in concept to the Athena SWAN program to advance gender equality in the United Kingdom (https://www.ecu.ac.uk/equality-charters/athena-swan/).

Stakeholder organizations and readers from all career stages interested in the content of this meeting and paper are encouraged to become involved in a follow-up mentoring meeting to take place in 2019 to drive grassroots efforts in affecting change in the mentoring landscape in STEM (http://www.futureofresearch.org/mentoring/).

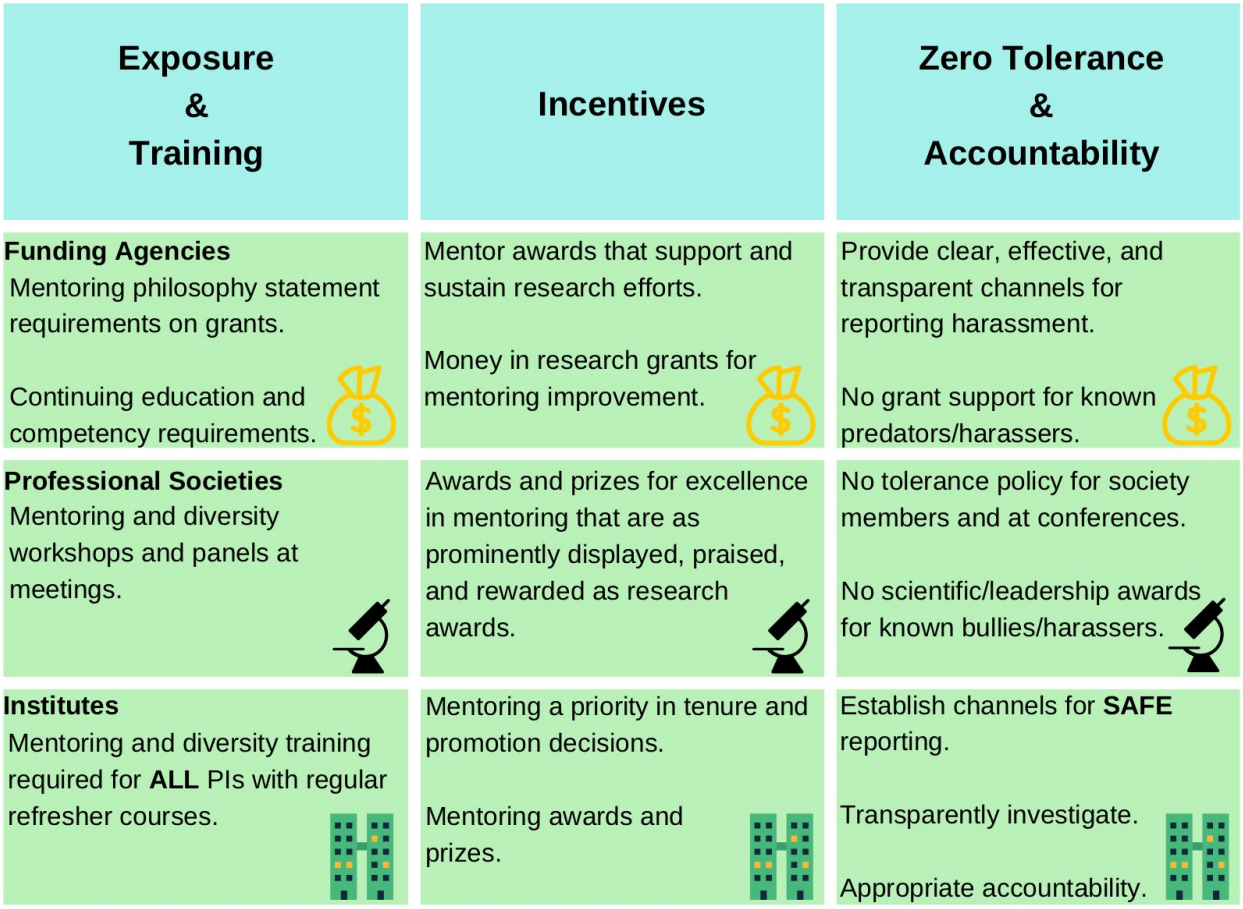

Figure 5. Call to action for funding agencies, professional societies, and institutes. The main barriers to effective mentoring were recognized to be due to a lack of exposure to and training in best mentoring practices, as well as a lack of incentives for good mentoring and accountability for negligent and toxic mentoring. We provide clear next steps for funding agencies, professional societies, and institutes to move towards actionable change to improve mentoring.

Acknowledgements

We would like to thank all those who participated in the meeting and twitter chat, especially our speakers, Dr. Sandra Quinn, Dr. Chris Pickett, and Brooke Deterline, as well as our panelists Dr. Belinda Lee Huang, Dr. Meg Bentley, Dr. Andres De Los Reyes, and Dr. Chinonye Nnakwe, who provided critical advice and insight into mentoring.

The meeting was made possible by a Career Development Symposia grant from the Genetics Society of America (GSA) and an Early Career Meeting Grant from the American Society for Cell Biology (ASCB), as well as generous contributions by the Union of Concerned Scientists (UCS) and Becton Dickinson (BD) Biosciences.

We'd also like to especially thank Dr. Blessing Enekwe from the UMD-College Park Office of Postdoctoral Affairs and Graduate School, Amanda Straus from the school's accessibility office, and their graduate student volunteers, for playing a vital role in the organization and hosting of this important meeting.

We would also like to thank Dr. Sonia Hall for insightful comments and help editing this manuscript.

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