Johns Hopkins University

Report on the Biomedical Research Enterprise

Committee on the Biomedical Scientific Workforce

September 2018

Contents

Introduction

On October 25, 2016, President Ronald J. Daniels and Provost Sunil Kumar launched the work of this Committee to consider the challenges and needs of the biomedical research community at our university.

Although the U.S. system of biomedical research has been a driver of unrivaled discovery and innovation for over half a century, it is now facing serious challenges that have attracted national attention. The mandate that President Daniels and Provost Kumar issued to this Committee touched on a number of these challenges: a persistent decline in the purchasing power of NIH funding; the widening of the period between the conferral of a doctoral degree and the receipt of independent research grants; the tightening of opportunities for careers as a tenure-track faculty member and the lack of well-developed pathways for alternate careers; the enduring gender and racial inequities; the pressure to obtain grants and publications in an era of austerity; and the emergent view that the incentives in the current system contribute to a culture of hyper-competition and conservatism for the incoming generation at a moment when we should be emphasizing creativity, collegiality, and team-based science.

The mandate also noted that in recent years a cascade of reforms at the NIH addressed these problems, but far fewer similar efforts were made at research universities, despite their central role in the biomedical research ecosystem. And so, the mandate called on this Committee to consider steps we should take as a university to strengthen our enterprise for the next generation of biomedical investigators. The mandate invited the committee to explore such issues as the adequacy of resources for independent research by investigators, the development of career paths for non-academic settings, and the strengthening and staffing of core facilities. The mandate called on us to consider the innovative practices and initiatives already underway in our schools and divisions, as well as those beyond our university, in order to identify areas of needed change in our own approach and set out a blueprint for reform. The full mandate of the Committee can be found in **Appendix A.**

The Committee was chaired by Wendy Post, professor of medicine at the School of Medicine and professor of epidemiology at the Bloomberg School of Public Health, and Pierre Coulombe, the E.V. McCollum Professor and chair of the Department of Biochemistry and Molecular Biology at the Bloomberg School of Public Health. The Committee comprised faculty, staff, and students from across the biomedical divisions of the university: the School of Medicine, the Bloomberg School of Public Health, the Krieger School of Arts and Sciences, the Whiting School of Engineering, the School of Nursing, and the Applied Physics Laboratory.

The Committee extends its appreciation in particular to Peter Espenshade, who chaired its Training Subcommittee; Janice Clements and Chiadi Ndumele, who co-chaired its Faculty Subcommittee; and Larry Akio Nagahara and David Mohr, who co-chaired its Labs and Infrastructure Subcommittee. Denis Wirtz and Kelly Gebo of the Provost's Office played central roles. In addition, key support was provided by Stephen Ruckman and Phil Spector from the President's Office. The full membership of the Committee can be found in **Appendix B.**

Since its launch last year, the Committee has met, either together or in subcommittee, on more than two dozen occasions. The Committee convened over a dozen focus groups with senior and junior faculty, postdoctoral researchers, students, and staff, and met separately with individual stakeholders from across the university. The Committee requested and reviewed data on the biomedical landscape at Johns Hopkins and extensively consulted scholarly articles and reports, and looked at activities at peer institutions. Finally, the Committee deliberated at length to produce the findings and recommendations for further action contained in this draft report.

Our view is that the state of the biomedical faculty, students, and staff at Johns Hopkins is strong. Our university continues to attract more NIH funding than any other university in the United States and draw from the most talented researchers across the globe. It is regarded as a world-renowned home to cutting-edge and impactful research that is advancing the frontiers of knowledge and producing the discoveries and cures of tomorrow. The Committee took special note of the multiple ways in which the university is already home to bracing examples of experimentation and leadership in the training and support of the biomedical workforce. The university accomplishes all of this even though it operates on a small endowment, relative to its peers.

At the same time, we cannot neglect the ways in which the landscape of biomedical research is shifting underfoot. The sector is roiled by the implications of a decline in federal research funding, an imbalance between available trainees and the number of faculty positions, the absence of stable nonfaculty research tracks, enduring issues for underrepresented and vulnerable populations, and widespread concern that the system is failing to incentivize true experimentation and creativity, or collaborative, team-based science. These stressors have produced widespread concern that a culture of hyper-competition is having a negative impact on both our scientists and the science they produce, and may be contributing to issues of reproducibility and accuracy. Science policy leaders now routinely identify "severe problems,"[1] "systematic flaws,"[2] and "dysfunction"[3] in reports and articles about the U.S. biomedical research system. Magnifying these challenges is that there is now greater competition for limited financial resources, owing to the surge of interest in biomedical research among academic institutions across the United States.

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1 Bruce Alberts et al., "Opinion: Addressing Systemic Problems in the Biomedical Research Enterprise," PNAS 112, no. 7 (February 2015).

2 Judith Kimble et al., "Strategies from UW-Madison for Rescuing Biomedical Research in the US," eLife 2015.

3 Arturo Casadevall and Ferric C Fang, "Reforming Science: Methodological and Cultural Reforms," *Infection and Immunity* 85, no. 6 (June 2017).

It is our responsibility as caretakers of the research enterprise at the university never to shy away from self-examination, from questioning how we can adapt our programs, refine our approach, and learn from others. The faculty we talked to in our review described Johns Hopkins as a place of remarkable innovation, collegiality, and freedom for exploration. But they also pointed to areas they thought were in need of improvement or reconsideration. And so, we took seriously our charge to be unflinching in our scrutiny of our own practices and expansive in our imagination of the promise ahead.

It is in this spirit that we offer 24 recommendations in this report.

The recommendations are animated by the following eight values that we see as essential to the future of a healthy biomedical enterprise:

- **Transparency.** We owe it to our trainees to make available to them the data and information they need to make informed choices about their training and career paths.
- **Diversity.** The absence of true diversity in the biomedical workforce is an enduring problem that requires attention, and we must be unflagging in our commitment to recruit and support a diverse cadre of scientists at our university.
- **Mentorship.** The relationship between mentor or principal investigator and trainee will be one of the most powerful forces shaping the trajectory of the next generation of scientists, and we should promote and strengthen that relationship where possible.
- **Advancement.** We need to create platforms that permit the advancement of our trainees, staff, and faculty for a diversity of highly productive careers for which they are suited.
- **Protected Time.** We must take steps to ensure that the great pressures of the current funding environment do not crowd out entirely time for training, career development, or the creative endeavor.
- **Innovation.** We must stay acutely focused on the creativity and risk taking that are the hallmark of Johns Hopkins. Where obstacles exist to that creativity, we should take steps to address them.
- **Collaboration and Team Science.** The future of the biomedical enterprise lies in team- based science to a significant degree, but the incentives in the biomedical enterprise do not always align with this goal.
- **Organizational Efficiency.** Our university's biomedical research enterprise is a highly distributed system, and in some areas the lack of coordination among its various components—finance, infrastructure, and personnel—undercuts the effectiveness of our science.

We developed the proposals described below mindful that our biomedical research ecosystem is a complex enterprise, with many stakeholders and interlocking pieces, and that the solutions to any problems are more likely to emerge from a long view and a number of thoughtful changes over time rather than from any single or sudden intervention.

Some of the recommendations have already been adopted in one or more Johns Hopkins University divisions and, we believe, merit expansion across the university. For others, we drew inspiration from outside our campus walls. For still others, we recommend pilot projects or experimentation funds to test the ideas with rigorous observation and analysis of outcomes, in the finest tradition of the very science we seek to support. We are encouraged that a number of our proposals align with the recommendations in the recent report of a committee of the National Academies of Sciences, Engineering and Medicine[4] (which President Daniels chaired) and the commitments of the new Coalition for Next Generation Life Sciences (which our university helped to launch).

Some of the recommendations may have implications for our university beyond the biomedical disciplines. Proposals specific to biomedical doctoral programs, for instance, may be relevant to degree programs outside the scope of the Committee; others may make sense only for biomedical degree programs and should not be applied more broadly. In this regard, we anticipate that our biomedical disciplines can serve as laboratories for at least some of these ideas, which might then, only if successful and after further discussion and study, be scaled to other programs and divisions at the university.

Many of the recommendations can be implemented immediately. Others will require additional policy development and consultations or other follow-on work on specific topics. And a number are more far-reaching still, contingent on funding and philanthropy. The Committee did not allow itself to be deterred by these hurdles when articulating its recommendations; it understood that progress requires time and resources, but it also requires a clear statement of goals and objectives. The Committee firmly believes that these recommendations are intended to be more than aspirational, and that, when implemented, the university should determine an appropriate mechanism to ensure compliance. The Committee also underscores its finding that the renewal of our research enterprise for the next generation must also involve a search for inefficiencies in our current approach that can be captured to support the goals of the future.

Throughout, our goal is to lend our ideas to the ongoing conversation across the university about how to create the strongest possible platform for the success of our trainees, staff, and faculty.

We submit the recommendations that follow in that spirit—and in honor of our scientists and the boundless science they imagine.

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4 National Academies of Sciences, Engineering, and Medicine. 2018. *The Next Generation of Biomedical and Behavioral Sciences Researchers: Breaking Through*. Washington, DC: The National Academies Press

Executive Summary

The Committee deliberated for many months on the biomedical research community at Johns Hopkins, and consulted faculty, staff, and trainees from across the university. Its top-line findings are as follows:

- The state of the biomedical research enterprise at Johns Hopkins University is strong. Our university is widely recognized as one of the global leaders in biomedical discovery and innovation and in training the next generation of researchers.
- Nationally, there are strains in the biomedical research enterprise, specifically with regard to how we train for a multiplicity of career options, how faculty—particularly minority and women faculty—are supported at a moment of funding austerity, and how science is conducted in laboratories. Johns Hopkins University is not immune to these strains.
- Johns Hopkins University should play a leadership role in identifying and developing solutions to these stresses. This is our legacy as the birthplace of modern doctoral education and the apprenticeship model of postdoctoral training, as well our enduring responsibility to our scientists and the science they produce.
- Although the university has robust career development offerings, we can still do more to strengthen the way in which we support our trainees as they consider a broad range of training and career paths, especially in the areas of information, mentorship, and time for skills development.
- Our faculty would benefit from shared or pooled resources, additional financial investment for research, and ongoing attention to work-life and diversity challenges.
- Likewise, there are areas where improved coordination among scientists, laboratories, and core facilities would substantially facilitate the conduct of our science, without impairing the freedom that is the hallmark of our institution.
- These are complex problems involving a range of stakeholders in a distributed and varied research ecosystem, and so, where possible, we favor experimentation with new approaches.
- The needs of the ecosystem are varied. In some areas, we believe new policies or processes can provide enormous lift; for example, we propose new mechanisms to rationalize our use of cores. In others, we suggest new financial investments, to strengthen areas of vulnerability for our investigators. In still others, we find that the university is already leaning into reforms—for instance, in the areas of transparency and diversity—and we applaud these efforts, in some cases recommending they be fully resourced, in others proposing refinements.

These findings animate the recommendations that follow, which are organized into three sections.

Part One: Training and Professional Development

Promote an academic culture that enables and supports professional growth and career development while embracing work-life balance.

1. Require annual individual development plan (IDP) completion and submission for PhD registration and postdoctoral reappointment.
2. Develop a universitywide set of expectations for faculty mentors of PhDs and postdoctoral fellows in the biomedical sciences.
3. Provide PhD and postdoctoral trainees an average of at least one hour per week of protected time for professional development.
4. Make additional investments in career development offices supporting trainees seeking diverse biomedical careers.
5. Limit postdoctoral research appointments to five years, with a possible extension in extenuating circumstances.
6. Strengthen the processes and resources for the orientation and integration of new biomedical faculty.
7. Prioritize the recruitment, retention, and advancement of diverse faculty.
8. Ensure that non-tenure-track biomedical research positions are on a career track with defined opportunities and criteria for promotion and/or advancement.
9. Model and support a culture of work-life integration and well-being.

Part Two: Transparency and Coordination

Provide comprehensive data and scaled resources for the aspirations of our biomedical research community.

10. Publish online data on training outcomes for biomedical science PhD and postdoctoral programs, to include at a minimum: (a) time to degree completion or time spent in postdoctoral training; and (b) career placement.
11. Promote and reward collaboration among biomedical faculty.
12. Establish a Research Core Coordinating Committee to provide oversight and coordination of research core activities and policies.
13. Promote the acquisition of key biomedical instrumentation on a shared basis.
14. Strengthen the university's coordination with nonfederal entities for investment in biomedical research facilities.
15. Expand the Core Coins Program, and use this mechanism to strengthen support for junior faculty.
16. Review current promotion policies across the schools to ensure that they reward innovation, collaboration, mentorship, and excellence in the various aspects of the JHU mission, including teaching, practice, and service.

Part Three: Funding and Resources

Create platforms of support for biomedical faculty to advance the joy of shared discovery, with a particular focus on the needs of early career investigators.

17. Continue and consider expanding the Catalyst and Discovery awards.
18. Initiate a new Bridge Award for high-performing faculty targeted to vulnerable periods in their careers.
19. Expand shared resources for administrative and research support for the preparation and execution of grants.
20. Establish a Biomedical Enterprise Innovation Fund to promote experimentation in the functioning of our biomedical research enterprise.
21. Make financial support for biomedical PhD students and postdoctoral fellowships a development priority.
22. Increase the guaranteed salary support for faculty engaged in biomedical research.
23. Include in the design of biomedical research and training facilities attention to spaces that promote interaction among trainees, faculty, and staff in different disciplines.

Conclusion

24. Identify a leader responsible for implementing these recommendations and a cross-university body to provide oversight.

Part One:
Training and Professional Development

Our trainees represent the future of the biomedical research enterprise. Today's biomedical trainees will be tomorrow's academic faculty and staff, industry researchers, biotech entrepreneurs, and science policy leaders.[5]

Nationally, there is growing concern about the state of the trainee population. Biomedical trainees enroll in PhDs and postdoctoral fellowships first and foremost to undertake training in preparation for their own careers, not to toil for others. Widespread reports suggest, however, that they do not receive access to the training, mentorship, and information they need to make informed career choices. Instead of preparing trainees for the full range of career paths, the research enterprise may even actively steer them toward academic positions, though only a minority will become faculty members.[6]

Meanwhile, postdoctoral fellows find themselves waiting for ever-longer periods, to uncertain ends. Faculty often must wear two hats—of mentor and of grantee—and this duality creates a tension over their values, namely how to support their trainees while also delivering efficiently on their grant. There is concern that trainees and early career faculty are exposed to a culture of hyper-competition that can discourage team-based science and promote individualism. Finally, evidence shows that all these pressures can place a particular burden on certain trainee populations and that gains in the recruitment of a diverse trainee population nationwide have not translated into the faculty population.[7] This is no less true at our own institution; our most recent faculty composition report shows that underrepresented minorities make up only 7 percent of full-time basic sciences faculty at the School of Medicine and only 4 percent of full-time biology faculty at the Krieger School of Arts and Sciences.[8]

Johns Hopkins is the birthplace of the research university in the United States, as well as the home of modern doctoral education in the life sciences and the apprenticeship model of postdoctoral training.[9] Our commitment to trainees must seek to honor this legacy by providing them with a first-in-class

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5 The Committee chose not to offer recommendations specifically on the training of physicians, in no small part because this area is heavily regulated by national accrediting bodies such as the LCME and ACGME.

6 According to one recent study, 23 percent of biomedical PhD recipients receive tenure-track academic research or teaching positions, and 20 percent receive nontenured academic research or teaching positions. National Institutes of Health, *Biomedical Research Workforce Working Group Report*, 2012.

7 Lindsay C. Meyers et al., "Survey of Checkpoints along the Pathway to Diverse Biomedical Research Faculty," *PLoS ONE* 13, no. 1 (2018). "While there has been increased representation of underrepresented groups in biomedical graduate education, those underrepresented groups are not showing up in tenure track faculty positions at levels that reflect either the demographics of the population at large or the number of URM trainees who have completed doctoral education."

8 JHU Report on Faculty Composition, September 2016.

9 Institute of Medicine, National Academy of Sciences, National Academy of Engineering, *Enhancing the Postdoctoral Experience for Scientists and Engineers: A Guide for Postdoctoral Scholars, Advisers, Institutions, Funding Organizations, and Disciplinary Societies* (National Academies Press, 2000).

training and academic experience and encouraging them to become exemplary scientists in whatever biomedical career suits them best. This must include a strong and effective portfolio of professional and career development opportunities to support our trainees exploring a diversity of career options.

We have in many respects been an innovator in these areas, especially in the last five years. From the OPTIONS program (which creates a structured multiyear career development track for trainees) to XDBio (a new cross-disciplinary biosciences PhD program with accelerated time to independence); from the MedImmune partnership (which includes a joint program to train PhDs for careers in biopharma) to the Preparing Future Faculty Teaching Academy (which provides an introduction to effective teaching practices), our university has launched a number of cutting-edge initiatives to prepare our trainees for a diverse range of career options. Notwithstanding these recent initiatives, a number of the structural stressors on the national stage continue to echo through our conversations with biomedical PhDs and postdoctoral fellows at our university.

Above all, our polestar must be that the graduate student experience and postdoctoral fellowship should be about training. In our programs and our treatment of these individuals, the focus at all times should be on teaching and training them for productive careers as scientists. The recommendations we provide below are written with that axiom squarely in mind.

1. Require annual individual development plan (IDP) completion and submission for PhD registration and postdoctoral reappointment.

In its consultations, the Committee heard from numerous trainees that faculty-trainee mentoring was inconsistent at the university. These same concerns are echoed in PhD exit surveys. Although many trainees reported deeply satisfying mentorship experiences, others expressed frustration with the lack of guidance they received from their faculty advisors. Faculty, for their part, reported challenges in providing good mentorship in the absence of information from their students and postdocs about their specific career needs.

One tool that is designed to facilitate a closer meeting of the minds is the individual development plan, or IDP, a set of professional and career goals that trainees write at the start of their training and review annually with their faculty advisors. The completion and the review of these plans provide an opportunity for communication about goals and expectations of both the trainee and the principal investigator(s), and offer an opportunity to discuss diverse careers and how to prepare for them. As one Committee member put it, no trainee arrives at the university with the “whole package” of skills they need for career success (research, writing, running an experiment, managing time effectively, working in teams); the IDP process helps the mentee identify and seek out the parts of the package they are missing for their desired career, whether in academia or elsewhere, and helps the mentor determine how to prepare them accordingly. Studies have shown that the IDP has a substantial, positive impact on the trainee experience.[10] Our own trainees expressed to the Committee their appreciation for these plans and the conversations they facilitate when they are used.

Our Doctor of Philosophy Board has endorsed a requirement that all advisors develop an individualized learning plan with their PhD students. However, the Committee heard repeatedly that, in practice, this rule is not followed consistently. Although some divisions encourage the use of IDPs for postdoctoral fellows,[11] very few, to the Committee's knowledge, require that they be completed. The Committee believes that the IDP is an essential component of the trainee experience and should be treated as such. Accordingly, the Committee recommends that the university require the annual completion of an IDP with a mentor or advisor as a condition for a doctoral student to register for courses or a postdoctoral fellow to be reappointed.

Linking the IDP to registration and reappointment incentivizes compliance by both the trainee and the advisor, who is deprived of the opportunity to work with the trainee if the trainee cannot report to the lab. But, the Committee expects those charged with implementing this recommendation to consider other options to ensure compliance on the part of advisors in the event this mechanism is ineffective or places undue burden on he trainee.

The Committee underscores that the submission of the IDP should not be the end of the process but should lead to an ongoing discussion between the trainee and the mentor about its contents and the trainee's goals. The Committee also notes that since a number of different models for IDPs are in use across the university, their content should be reviewed to ensure that they include the essential ingredients to promote a meaningful trainee conversation.

2. Develop a universitywide set of expectations for faculty mentors of PhDs and postdoctoral fellows in the biomedical sciences.

Although the university has published principles for faculty mentorship of junior faculty, it has not yet developeded similar universitywide principles for faculty mentorship of trainees. The trainees we talked with noted its absence. Although there is a university Statement of Rights and Responsibilities for PhD students that includes a reference to the right to "training" and "appropriate and regular faculty supervision," it falls short of what we might regard as a meaningful set of mentorship expectations. By way of comparison, Stanford University's biosciences IDP places on the first page a list of essential elements of a successful mentoring relationship, and on a second page a fuller list of student and advisor responsibilities. Students are encouraged to read and discuss the lists with their advisor when they meet.[13]

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10 One analysis of a national survey of more than 7,000 postdoctoral researchers found that those who developed a plan with their advisor at the beginning of their appointments reported higher satisfaction, a better relationship with their advisor, reduced conflict, and increased research output. In fact, a training plan was the *only* factor in the analysis that was associated in a statistically significant manner with all four of those measures of success.

11 Johns Hopkins Medicine, School of Medicine, "Selection, Appointment, and Evaluation of Postdoctoral Fellows," http://www.hopkinsmedicine.org/som/gme/fellows/SelectApptEvalPromDismissal-2014.pdf.

12 Principles of Faculty Mentoring, February 16, 2015, available at http://web.jhu.edu/administration/provost/docs/Principles-Mentoring_Amended16Feb2015.pdf.

13 Stanford Biosciences, "Your Individual Development Plan and Planning Meetings," https://biosciences.stanford.edu/current/idp/; IDP Forms and Documents, https://biosciences.stanford.edu/current/idp/forms.html.

A set of expectations for faculty mentors need not be particularly prescriptive; principles or guideposts are what is called for here, rather than rules. The objective is to set out a brief list of expectations that reflect a commitment to certain minimum standards, on the part of both the trainer and the trainee, to guide the mentoring process. And if included as an ingredient of a structured trainer-trainee IDP requirement, this list could play a key role in facilitating common understanding on how best to use the training period to prepare for one's desired career.

Therefore, we recommend that the university develop a set of expectations for biomedical faculty mentors and PhDs and postdoctoral fellows, with input from graduate students and other trainees, and that those expectations be included as part of the IDP as an annual reminder of commitments by mentor and mentee. The Committee recommends that the expectations be not only placed in the IDP itself but also posted to relevant university websites and distributed to students during orientation.[14] The Committee also recommends that faculty receive the information they need in order to counsel students and trainees on the broadest possible range of biomedical career paths, or be able to direct them easily to people with personal experience in those career trajectories.

3. Provide PhD and postdoctoral trainees an average of at least one hour per week of protected time for professional development.

Professional development and career training are essential to an eventual career, whether that career is in academia, industry, or one of the many other options available to our trainees. A significant challenge for today's trainees is balancing the time-consuming demands of their day-to-day training—coursework and research—with the need to identify a career path and develop the professional skills necessary for that path. Many of the doctoral students and postdoctoral fellows the Committee talked to strongly praised the personnel and resources available to biomedical trainees in career development offices. However, they reported uncertainty about the amount of time away from work and studies that their advisors would view as appropriate for professional development, noting in some cases that principal investigators were inflexible when they sought to take such time.

National reports have called on universities to provide their trainees with protected time for career development activities.[15] The National Institutes of Health has since clarified that trainees on research grants are permitted to take such time.[16] Universities are slowly beginning to see the importance of self-directed protected time, but very few are taking steps to guarantee it, and when they are, it

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14 KSAS and WSE has identified, with the Homewood Postdoctoral Association, a list of postdoctoral fellow rights and responsibilities that could be a reference for the university-wide expectations discussed in this recommendation. Note that while Committee members want completion and review of IDPs to be a requirement, they do not want mentors and mentees to be contractually bound to fulfill the goals within them. IDPs are meant as guiding documents, not contracts.

15 See, for example, *The Postdoctoral Experience Revisited* (2014): 76.

16 Rachel Bernstein, "Yes, You Can Attend That Career Event, Says the Government," Science.com, Dec. 17, 2014, http://www.sciencemag.org/careers/2014/12/yes-you-can-attend-career-event-says-us-government.

tends to be more prescriptive in content.[17] Johns Hopkins can and should be a leader with regard to this issue. To ensure that the trainees' experience includes a component that is focused on preparing them for their next steps, the Committee recommends that the university provide each individual with a minimum of 2 percent of protected time, or an average of at least one hour per week, to take advantage of the range of career and professional development offerings available at Hopkins and elsewhere. This time could be used, for example, to participate in weekly professional development seminars; occasional one-day workshops or three-day trainings; or time away from the lab, in Baltimore or elsewhere, for targeted career development endeavors like externships or internships, such as those currently offered by the Biomedical Careers Initiative.

One example of such a program is OPTIONS, a new multiyear initiative that is being launched by the Johns Hopkins Graduate Training Program in Cellular and Molecular Medicine and the Johns Hopkins Medicine Professional Development and Career Office. During years one and two in the program, students will attend six one-hour events where they will learn about what our alumni are doing with their careers. In year three, students will select one of six "career communities"—research, business, teaching, administration, communication, or regulatory—that meet monthly and are led by faculty and alumni working in these fields to build skills and an understanding of how to prepare for their career choice.[18] In years four and beyond, students will choose an activity to increase their competitiveness for their chosen career. The OPTIONS program is trailblazing and a model for future thinking about how to integrate career training into graduate education, but it will be successful only if trainees are permitted the time to participate.[19]

4. Make additional investments in career development offices supporting trainees seeking diverse biomedical careers.

For guaranteed protected time to be used effectively, it needs to be matched by well-resourced career development offerings. Only a minority of biomedical trainees will enter a tenure-track academic position, and so the importance of robust career development offices for biomedical graduate

17 Emory University and Georgia Tech University have recently implemented a requirement for stage-specific professional development "boot camp" each year—roughly 12 hours per year over five years—with prescribed instruction. The University of Massachusetts Medical School requires students, as part of its curriculum, to participate in career development activities, including a course on career planning in their third year, and participation in Career Pathways Communities in their third and fourth years of training. UMass Medical School, Center for Biomedical Career Development, Graduate School of Biomedical Sciences, https://www.umassmed.edu/es/gsbs/career/pathways/overview/community/.

18 For instance, Johns Hopkins Tech Ventures and Carey Business School faculty will teach students interested in a career in business how to write a business plan using a Johns Hopkins biomedical invention.

19 Implementers of this recommendation should keep in mind that they need to ensure that this time is being tracked in a manner consistent with the goals of this recommendation. The Committee does recommend that the amount of time that students are able to take for career development activities be added to university survey instruments.

students and postdocs has been noted in numerous national reports,[20] as well as prior Hopkins reports, such as the 2015 report of the PhD & Postdoctoral Fellow Career and Professional Development Working Group. And a 2015–16 survey of enrolled PhD students revealed dissatisfaction with resources for nonacademic career options. Many of the trainees the Committee consulted also expressed concern that the career development offerings that do exist at the university do not have sufficient visibility; faculty also told the Committee that they are often unaware of university resources their mentees may find helpful.

Our professional and career development offices do strong work and offer innovative programs, but there is reason to believe they are under-resourced. Currently, the university has only 6.5 FTEs dedicated to providing career development services to its over 5,000 PhDs and postdocs in all disciplines. The Biomedical Careers Initiative, or BCI, does outstanding work in directing biomedical trainees to Hopkins' various career development resources, but where these resources are lacking, BCI cannot fill the gaps on its own. Meanwhile, a number of NIH BEST institutions have developed entire, fully integrated career development offices with several staff members dedicated solely to biomedical trainees.[21] Another stand-alone office may not necessarily be the best way to meet our trainees' needs, but its emergence at peer institutions is evidence of a renewed focus on the biomedical trainee population.

The Committee recommends that the university make robust resources available to career development offices supporting biomedical trainees, in order to ensure they are exposed to the skills and opportunities that will help them succeed in a range of careers. This includes expanding industry partnerships and providing personal development that facilitates career training no matter what path a trainee chooses.

5. **Limit postdoctoral research appointments to five years, with a possible extension in extenuating circumstances.**

The duration of the biomedical postdoctoral fellowship is a source of stress for our trainees, and those nationwide. Talented, young biomedical scientists now find themselves spending some of their most productive years in what were meant to be temporary positions that lack opportunities for long-term advancement or independent research. Although data on postdoctoral fellowships is imperfect, it is not unusual nationally "to find biomedical researchers who have completed several postdoctoral

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20 *Enhancing the Postdoctoral Experience for Scientists and Engineers* (National Academies Press, 2000): 76. This National Academies report describes the creation of a postdoctoral career development office as a best practice. *Biomedical Research Workforce Working Group Report* (NIH, 2012): 38. This report, by a working group of the Advisory Committee to the Director of NIH, calls on NIH to "create a pilot program for institutional postdoctoral offices to compete for funding to experiment in enriching and diversifying postdoctoral training, including partnerships with other entities (industry, private foundations, government, etc.)." *The Postdoctoral Experience Revisited* (National Academies Press2014): 8. This National Academies report recommends that each institution have a "strong and separate or stand-alone postdoctoral office."

21 Frederick J. Meyers et al., "The Origin and Implementation of the Broadening Experiences in Scientific Training Programs: An NIH Common Fund Initiative," *The FASEB Journal* 30, no. 2 (February 2016): 507–14; Vanderbilt University School of Medicine, BRET Career Development, https://medschool.vanderbilt.edu/career-development/.

appointments that total more than 5 years."[22] One study indicated that of the "more than 40,000 US biomedical postdocs in 2013, almost 4,000 had been so for more than 6 years."[23]

A report by the National Academies of Sciences, Engineering, and Medicine first called for a five-year cap on the duration of postdoctoral fellowships nearly two decades ago.[24] The NIH,[25] the NSF,[26] the National Postdoctoral Association[27] and multiple other reports by national panels and science policy leaders[28] have since followed suit. According to one report, 63 percent of institutions cap the length of postdoctoral appointment at five years.[29] This includes many of our peers, such as New York University School of Medicine and the University of California system. Our peer institutions report that a strict cap helps address two related problems: "The first is the 'just one more year, experiment, or paper' syndrome, in which postdocs feel that they must endlessly build their academic CV before moving on. The second is the 'permadoc' who stays on indefinitely, eventually runs into his or her advisor's retirement and is stranded without a job."[30]

The Johns Hopkins School of Medicine currently has a six-year limit on postdoctoral fellowships, with up to 12 additional months permitted only after review and approval by the associate dean for postdoctoral affairs. Time beyond seven years is permitted only under "extreme or extenuating" circumstances.[31] There is currently no fellowship term limit at the Bloomberg School of Public Health, the Krieger School of Arts and Sciences, or the Whiting School of Engineering.[32]

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22 *The Postdoctoral Experience Revisited* (2014): 25.

23 Kendall Powell, "The Future of the Postdoc," *Nature News & Comment* (April 7, 2015). There is no comprehensive data on fellowship durations across the university, but School of Medicine data show that more than 6 percent of PhD-trained postdoctoral fellows were in a fellowship at Johns Hopkins for more than six years. The number is likely quite a bit higher if one excludes appointees who receive a "postdoctoral fellow" title but who aren't a traditional postdoctoral researcher as one normally understands the term; they may be visitors doing brief stints at the university or grad students doing short holdovers from their PhD. As noted earlier, we recommend strengthened data collection and transparency for trainees.

24 *Enhancing the Postdoctoral Experience for Scientists and Engineers*, 3.

25 NIH Statement in Response to the NAS Report: Addressing the Nation's Changing Needs for Biomedical and Behavioral Scientists (NOT-OD-01-027, Mar. 22, 2001). "Universities should consider conversion of all individuals in postdoctoral training to staff or faculty appointments at the earliest possible opportunity. Certainly, by five years of postdoctoral training experience, training should be completed and individuals who are being retained at the institution should be converted to non-training positions that provide appropriate levels of income and a benefit package that includes such items as retirement, leave, and health insurance."

26 National Research Council, *Bridges to Independence: Fostering the Independence of New Investigators in Biomedical Research* (National Academies Press, 2005): 5. "Five years is meant to be the maximum duration of a postdoctoral position, with the expected duration much shorter. A postdoctoral tenure should last only as long as is needed to prepare the investigator for the next career stage. The committee hopes that the normal length of postdoctoral training will be closer to 3 years, whether in one or multiple environments."

27 "NPA Responds to NAS' *The Postdoctoral Experience Revisited*" (National Postdoctoral Association, Dec. 17, 2014). "The NPA believes that the postdoctoral experience should be a temporary, defined period of mentored training, consistent with the National Science Foundation (NSF) and the National Institutes of Health (NIH) definition of (a maximum of) five years in duration," http://www.nationalpostdoc.org/?page=NPANASReponse&hhSearchTerms=%22%22five+years%22%22.

28 *Bridges to Independence* (National Academies Press, 2005); *The Postdoctoral Experience Revisited* (National Academies Press, 2014); Bruce Alberts et al., "Rescuing Biomedical Research from Its Systemic Flaws," *Proceedings of the National Academy of Sciences* (April 2014), http://www.pnas.org/content/111/16/5773.full. This article recommends a "limit [on] the total number of years that a postdoctoral fellow may be supported by federal research grants."

29 National Postdoctoral Association, Institutional Policy Report (2014): 13.

30 Kendall Powell, "The Future of the Postdoc," *Nature News & Comment* (April 7, 2015).

31 Johns Hopkins Medicine, School of Medicine, Selection, Appointment, and Evaluation of Postdoctoral Fellows, http://www.hopkinsmedicine.org/som/gme/fellows/SelectApptEvalPromDismissal-2014.pdf.

32 The Whiting School's postdoctoral policies do state, however, that "renewals for postdoctoral fellows who are 6+ years past their PhD will have to be justified," http://postdoc.jhu.edu/postdoc-info/handbook/policies/.

The Committee recommends that we join our peer institutions in establishing a five-year cap, with a possible extension in extenuating circumstances, to encourage responsible planning and help tease apart some of the worst excesses of the current system. Extenuating circumstances include situations where a trainee needs to switch PIs for unforeseen reasons, changes the focus of their training in a way requiring additional training, or confronts medical or family issues that require a leave of absence. To be sure, questions will need to be answered—among them how to define a postdoctoral fellowship, when and how to allow extensions of time, whether there should be particular flexibility for certain disciplines, and how to ensure that fellows transition to robust and sustainable nontrainee, non-tenure-track careers, rather than just a postdoctoral fellowship by a different name (see Recommendation 8 below). But the essence of this recommendation remains: a five-year cap as a general rule, to return the postdoctoral fellowship to its original purpose as a moment of transition to a productive scientific or research career.

6. Strengthen the processes and resources for the orientation and integration of new biomedical faculty.

Although exceptions certainly exist, many early career biomedical faculty pointed to a lack of orientation to the institution and its policies and resources as an area of concern. A typical early career faculty member said, "I don't know what orientation is available for assistant professors, but [in my case] there was nothing [provided]." Faculty we talked to offered that they would have greatly appreciated assistance in a number of areas, from how to start a laboratory and how to pay a purchase order, to teaching expectations and resources and student advising. Faculty explained that the absence of onboarding specific to the practice of biomedical research had hamstrung their initial productivity and left them feeling, from the start, disconnected from the institution.

The Committee found that our divisions do a strong job of providing information on policies and procedures in areas such as appointments and the promotion process. They could, however, do more when it comes to onboarding faculty, acquainting them with the nuts and bolts of how to operate in the university as a successful researcher, teacher, and mentor, and how to launch a productive, successful, and long-lasting biomedical research program at JHU.

Therefore, the Committee recommends a number of connected reforms: First, schools that do not presently offer a new-faculty orientation should start one. Second, because it is difficult for any single orientation program to touch all the faculty who arrive at various points throughout the year, each division should issue an easily accessible comprehensive handbook that addresses the resources available at the school, ranging from advice on how to start a laboratory, to teaching expectations and resources, to research support and library services and tools. The handbook should be stage-specific (e.g., junior versus established faculty) and track-specific (e.g., clinical versus research).

Department chairs or their representatives should reinforce the presence of these resources, update them regularly, and monitor whether their early career faculty are using them. Finally, departments should adopt a practice that is now underway in parts of the university, where annual meetings with assistant and associate professors include discussion of the faculty member's own individual development plan.

7. Prioritize the recruitment, retention, and advancement of diverse faculty.

The presence of a diverse workforce enhances the breadth and innovation of investigative work within academic medical centers. The diversity of the biomedical enterprise is a societal imperative that speaks directly to the sustainability and growth of research institutions. Unfortunately, tenure-track faculty continue to be predominantly male and white; women and underrepresented minorities, or URMs, nationally and at Hopkins continue to lag behind in the biomedical professoriate.[33] National studies continue to show that African-American investigators are funded by NIH at half the rate of white scientists.[34] Women are less successful than men in renewing R01 or equivalent grants from NIH.[35] And others underrepresented in the academy generally, including disabled and LGBTQ faculty, continue to face barriers in biomedical departments in particular.[36]

To strengthen our gains on recruitment and retention, the university has launched a multi-faceted Faculty Diversity Initiative, which includes new protocols for faculty searches to increase diversity within applicant pools,[37] outreach to professional societies for underrepresented groups, funding to support the recruitment of underrepresented minority scholars, a new fund for visiting faculty members, a postdoctoral fellow program, and an award for excellence in diversity and inclusion outreach. The Committee applauds these steps. But there are aspects of this problem at a research university that may be specific to the biomedical workforce and demand their own interventions.

These challenges include, but are not limited to, the difficulties underrepresented minorities face in establishing mentorship relationships and developing professional networks; inadequate protected

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33 Kenneth D. Gibbs Jr. et al., "Biomedical Science Ph.D. Career Interest Patterns by Race/Ethnicity and Gender," *PLoS ONE* 9, no. 12 (2014). "In the biomedical sciences (BMS), women earn more than half of Ph.Ds. but represent 33% of newly hired tenure/tenure-track (TTT) professors. Scientists from URM backgrounds earn 10% of life science Ph.Ds. but represent 2% of medical school basic science TTT faculty—a number unchanged since 1980." See note 6.

34 Donna K. Ginther et al., "Race, Ethnicity, and NIH Research Awards," *Science* 333, no. 6045 (2011). This study finds that African-American applicants are 13 percentage points less likely to receive NIH investigator-initiated research funding compared with whites. See also National Institutes of Health, "Racial Disparities in Research Funding," https://diversity.nih.gov/building-evidence/racial-disparities-nih-funding, which finds continued evidence of this disparity and others, e.g., in percentage of African-American scientists applying for R01s.

35 National Institutes of Health, Report on the Progress of Activities, The Advisory Committee to the Director Working Group on Diversity, June 8, 2017, https://acd.od.nih.gov/documents/presentations/06082017Valantine-Progress.pdf; W. Magua et al., "Are Female Applicants Disadvantaged in National Institutes of Health Peer Review? Combining Algorithmic Text Mining and Qualitative Methods to Detect Evaluative Differences in R01 Reviewers' Critiques," *Journal of Women's Health* 26, no. 5 (May 2017): 560–570.

36 Kathreen P. Lee et al., "Attitude and Perceptions of the Other Underrepresented Minority in Surgery," *Journal of Surgical Education* 71, no. 6 (2014). This national climate survey finds that "30% of LGBT residents did not reveal their sexual orientation when applying for general surgery residency owing to fear of not being accepted."

37 These include mandatory unconscious bias training for all search committee members, prioritizing candidate pools that reflect diverse candidate availability, and comprehensive reporting on search practices and activities. See https://diversity.jhu.edu/roadmap/faculty/ and https://diversity.jhu.edu/roadmap/faculty/.

time for research at the start of a biomedical research career, due to lower funding rates or a problematic workplace; financial pressures that may influence the choice of clinicians to pursue biomedical research versus a private practice career; the disproportionate time and effort spent by the limited number of faculty from underrepresented groups available to dedicate time to service activities; and the insufficient pipeline of underrepresented trainees pursuing biomedical research.

One possibility for addressing certain of these challenges is the NIH Diversity Supplements program, which offers additional funding to existing NIH grants with two or more award years left that enable investigators to recruit and retain diverse candidates (from faculty to trainees) with a demonstrated interest in research to fill crucial roles on research teams.[38] These supplements have high success rates and a short turnaround time, and analyses of the diversity supplements show a positive impact on career outcomes.[39] Although the university fares well with these supplements, with a success rate of roughly 50 percent, many are unaware that they are readily available.

Therefore, the Committee recommends that the Faculty Diversity Initiative add a formalized outreach component that encourages the use of diversity supplements in the biomedical workforce. Specifically, we recommend that when an investigator receives an R01, they be contacted to inform them about the potential availability of diversity supplements and the support of the university for their applications. The pursuit of supplements by investigators could be incentivized to reflect the expected mentorship activities associated with the award and further, that trainees who are under-represented minorities be notified that these supplements exist and encouraged to start a conversation with their mentors about these programs. These trainees could then be paired with networking, mentorship, and career development programming to facilitate the success of these awardees after the supplement ends, which is the ultimate goal of the program.

Of course, the issues here are complex and enduring and will not be addressable solely through interventions like the diversity supplement mechanism. Therefore, the Committee recommends that the mandate of the person(s) responsible for implementing these reforms (see Recommendation 24) explicitly include partnering with existing offices and committees within Johns Hopkins dedicated to increasing the representation of women and URM faculty and establishing an environment of inclusion and equitable treatment for all, prohibitive of discrimination and harassment. These include the JHU Office of Institutional Equity, the JHU Office of Diversity and Inclusion, the JHM Office of Diversity and Inclusion, and the School of Medicine's Office of Diversity and Cultural Competency. Additional steps to consider include the development of startup packages to address financial pressures influencing career choices of underrepresented faculty; expanded implicit bias training for faculty and trainees and the development of diversity and inclusion pedagogy; enhancing existing policies and

38 National Institutes of Health, "Research Supplements to Promote Diversity in Health-Related Research," https://grants.nih.gov/grants/guide/pa-files/PA-15-322.html.

39 Alison Hall et al., NIGMS Analysis of Supplements to Enhance Diversity 1989–2006 (May 28, 2015), https://www.nigms.nih.gov/Research/mechanisms/Pages/promotediversityFAQ.aspx/.

procedures specific to discrimination and harassment; giving greater weight to service activities in promotion applications; and support of programs designed to increase the pipeline of underrepresented biomedical trainees.

All of these steps must be taken with the understanding that addressing structural inequalities in the sciences in the United States, and achieving true inclusion for underrepresented faculty, requires concerted effort from all members of faculty and leadership, not just those specifically tasked with improving diversity.[40]

8. Ensure that non-tenure-track biomedical research positions are on a career track with defined opportunities and criteria for promotion.

The innovative biomedical research performed by Johns Hopkins faculty could not be completed without the assistance and expertise of the professional scientists staffing its many labs and cores. These individuals are frequently called "staff scientists" in the literature,[41] but the very term suggests that they are support staff first and scientists second, when the reality is the reverse. These are highly trained scientists—usually with PhDs, sometimes with prior doctoral training in the very lab they serve professionally—whose main distinction from faculty scientists is that they do not teach and apply for grants. In many respects, they are an anchor of the lab they serve, using their knowledge and experience to solve problems for faculty and trainees that push research in new directions.

Yet, as the Committee learned in its examination, their importance is not reflected in their employment status at the university. For example, a number of professional scientists in certain divisions lack defined ladders for promotion and the opportunity for the relative job security that tenure provides. Many of these scientists also are hired on one-year renewable contracts, creating further job uncertainty. Any number of the scientists we talked to in senior roles, such as core facilities director, had employment classifications that did not do justice to their training, experience, or level of responsibility.

The Committee deliberated at length on how best to address this set of issues and looked at professional scientist career development strategies at peer institutions.[42] Given the heterogeneity of professional scientist positions at the university in different divisions, the Committee agreed that it would not be feasible to recommend the implementation of one single career track for professional scientists across the university. Instead, it strongly recommends that each division develop a career track, with defined opportunities and criteria for promotion, and that individuals in these paths be tracked

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40 See generally *JHU Roadmap on Diversity and Inclusion*, which sets out other steps for addressing structural inequalities and building a more inclusive community university-wide, https://diversity.jhu.edu/roadmap/.

41 For example, see National Institutes of Health, Biomedical Research Workforce Working Group Report (2012).

42 Broad Institute. Vanderbilt University Medical Center has "Core Research Assistant I, II, III," then "Coordinator, Scientific Research Core Facility," then "Scientific Core Research Facility Manager; https://abrf.org/sites/default/files/temp/Committees/vanderbilt_2015_core_job_descriptions.pdf. The SLAC National Accelerator Lab at Stanford has four levels: "Associate Staff Scientist"(term position, at least 3 years, up to 5), "Staff Scientist" (continuing term), "Senior Staff Scientist" (continuing term), and "Distinguished Staff Scientist" (continuing term); https://www-group.slac.stanford.edu/ppa/SLAC_staff_development_plan_v4.1.pdf.

across the divisions.[43] The Committee also recommends that the divisions work with Human Resources to promote the hiring of junior staff scientists on multiyear contracts, where talent warrants, to provide greater career stability. Finally, the Committee recommends that professional scientists be permitted to serve as PIs on shared instrumentation grants.

9. Model and support a culture of work-life integration and well-being.

One of the refrains the Committee heard from many early career faculty concerned the intensity of work, unhappiness regarding work-life balance, and the absence of good models for such balance from senior colleagues. These concerns are echoed across the national biomedical workforce as federal funding declines for researchers and clinical demands rise for clinicians, but they seem to resonate with particular strength at Johns Hopkins. And while the intensity of work and the absence of work-life balance can, of course, lead to frustration, unhappiness, and exit for every part of the workforce, multiple reports indicate that these considerations may fall particularly heavily on women, as reflected in their lower interest in faculty positions relative to men.[44]

Johns Hopkins Medicine launched the Joy in Medicine Task Force to survey employees to assess their needs, review the literature, talk to peer institutions, and put forth a blueprint for boosting satisfaction for faculty and staff across the medical school and health system. The report from the task force identified the need for transformation of Johns Hopkins Medicine work culture to model "joy in medicine" as an enduring value. To that end a Wellness Office has been established and a Wellness Officer has been charged with improving work culture to foster a professional, productive, mutually-supportive work environment. In addition, the committee noted the need to model a cooperative system that fosters community and collegiality; the need to approach professional development, expanded pathways to promotion, continuing education, and specialized training with focus on advancement and retention; and the need to eliminate workplace inefficiencies created through non-value added tasks, poorly designed processes, inadequate resourcing, time-consuming workflows and underutilized team members.[45] Many of the recommendations, in particular those for work-life integration, are applicable to faculty across JHU. Other divisions in the university should review the findings and recommendations of the task force and are encouraged to implement those that make sense for their constiuency.

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43 We note that APL—although organized differently than the university in many respects—already has a version of this track, called "Professional Staff," which has five levels: Associate I, Associate II, Senior I, Senior II, and Principal. See JHU Applied Physics Laboratory, Professional Staff Classification Matrix, on file. The recommendation in the text is consistent with the recommendations of others to have studied this issue; the 2012 NIH *Biomedical Research Workforce Working Group Report* "urge[d] institutions to create position categories that reflect the value and stature of these researchers."

44 Kenneth D. Gibbs Jr. et al., "Biomedical Science Ph.D. Career Interest Patterns by Race/Ethnicity and Gender," *PLoS ONE* 9, no. 12 (2014); Kenneth D. Gibbs, Jr., "Career Development among American Biomedical Postdocs," *CBE Life Sciences Education* 14 (2015): 1-12; Hannah A. Valantine et al., "From the NIH: A Systems Approach to Increasing the Diversity of the Biomedical Research Workforce," *CBE Life Sciences Education* 15:fe4 (Fall 2016): 1–5. See generally National Institutes of Health, Report on the Progress of Activities, The Advisory Committee to the Director Working Group on Diversity, June 8, 2017, which notes, among other things, that "[r]esearch indicates that issues of gender inequality are part of an unsupportive culture and climate experienced in microenvironments, along with structural issues that negatively influence career advancement of women."

45 *Joy in Medicine: Report of the Dean's Task Force*, December 8, 2017.

Part Two:
Transparency and Coordination

Two overarching traits of a healthy biomedical research enterprise demand particular attention.

The first is transparency. One of the core challenges of a training system is providing people with the information they need to make informed choices about their training and career goals. Ample evidence shows that a deep and entrenched information asymmetry may be distorting the choices of trainees. Multiple studies have found a substantial mismatch between the aspirations of trainees at the outset of their careers and several years in. An increasing number of trainees linger for years in highly uncertain postdoctoral fellowships, even though recent research suggests that outside of tenure track academic positions, biomedical employers do not financially value the training or skills acquired in these fellowships. Additional transparency is not a panacea for these problems, but it is an essential ingredient of any solution to these enduring issues. This was a refrain we heard often in our discussions with trainees.

The second trait is some degree of coordination in the infrastructure and planning of the biomedical ecosystem. One of the great virtues of our university is the freedom given to our faculty to develop their own research projects. We have experienced this freedom ourselves throughout our careers, and we heard this same view echoed time and again in conversations with our colleagues during our deliberations. And yet, we also heard a countervailing sentiment—particularly at the outset of their careers, faculty perceived an underinvestment in shared resources to enable their scientific endeavors. The Committee found that there were a number of areas where the university could make deliberate and targeted investments in shared resources to support and empower the science of our faculty. And the Committee became convinced that if structured in a careful manner, these commitments would not only be fully consistent with the university's culture of discovery but would amplify that discovery for generations to come.

The recommendations that follow in this section are directed to strengthening the university's approach to these dual traits across the biomedical research enterprise.

10. Publish online data on training outcomes for biomedical science PhD and postdoctoral programs, to include at a minimum: (a) time to degree completion or time spent in postdoctoral training; and (b) career placement.

Aspiring biomedical scientists often have a sense of biomedical career pathways that does not align with the reality ahead. In a recent survey, 60 percent of biomedical and life science postdoctoral fellows said they pursued their fellowships primarily to obtain a tenure-track faculty position, but only about

11 percent of U.S. biological and life sciences PhDs go on to hold a tenure-track position within five years of graduation.[46] Publishing these data would go a long way toward eliminating the information asymmetries that prevent sound long-term decision making by prospective biomedical PhDs and postdocs. For these reasons, national reports have repeatedly called on research universities to collect and publish data on training outcomes that is readily available and can help trainees as they seek to chart the trajectory of their training and careers. And yet, universities have almost entirely failed to act.[47]

At Johns Hopkins, individual departments and programs often make certain aspects of this information available on request, and others—for example, Biochemistry, Cellular and Molecular Biology, and Cellular and Molecular Medicine—publish it for all to see.[48] But unlike peer institutions, such as Stanford or the University of Michigan,[49] we do not as a university publish in a comprehensive and easily available manner data on graduate student outcomes. We believe that the university has a moral imperative to begin to do so, not only for graduate students but postdoctoral fellows as well. Openly sharing these data will help our trainees make better choices early in their careers and seek out the biomedical training that is right for them. Withholding this information distorts decision making and contributes to a host of issues in the workforce, including the holding tank of postdoctoral fellowships and the failure of trainees to obtain training for career options outside academia.

We understand that the Provost's Office is undertaking an extensive initiative to to collect and publish a wide range of data for and about trainees across the entire university. The university has already published data on graduate student diversity, as well as information on admissions, enrollment, completion and time to degree for doctoral programs in departments across the university.

The university also helped to launch the Coalition for Next Generation Life Science, a coalition of universities and research institutions that has agreed to collect and publish a wide range of new data on outcomes for biomedical graduate students and postdoctoral fellows using common definitions and standards. Through the Coalition, the university has committed to publish data on the demographics of postdoctoral scholars by gender, underrepresented minority status, and citizenship status (completed July 1, 2018); time in postdoctoral training at the institution (by October 1, 2018), career outcomes for PhD alumni (by February 1, 2019), and career outcomes for postdoctoral alumni (by July

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46 Henry Sauermann and Michael Roach, "Why Pursue the Postdoc Path?" Science 352, no. 6286 (May 6, 2016): 663–664.

47 Federation of American Societies for Experimental Biology, *Sustaining Discovery in Biological and Medical Sciences: A Framework for Discussion* (2015); National Academy of Engineering and Institute of Medicine of the National Academies, *The Postdoctoral Experience Revisited* (2014); National Institutes of Health, *Biomedical Research Workforce Working Group Report* (2012); National Research Council of the National Academies, *Bridges to Independence: Fostering the Independence of New Investigators in Biomedical Research* (2005); National Academy of Sciences, *Reshaping the Graduate Education of Scientists and Engineers* (1995); National Research Council, *Assessing Research-Doctorate Programs: A Methodological Study* (2003); Association of American Universities Committee on Graduate Education, *Report and Recommendations* (1998).

48 Biochemistry, Cellular and Molecular Biology Graduate Program Alumni, http://bcmb.bs.jhmi.edu/alumni; Cellular and Molecular Medicine Program Alumni, http://cmm.jhmi.edu/index.php/students/our-graduates/.

49 The Stanford PhD Alumni Employment Project, http://web.stanford.edu/dept/pres-provost/irds/phdjobs; University of Michigan Rackham Graduate School, Program Statistics, https://secure.rackham.umich.edu/academic_information/program_statistics/.

1, 2019) We are glad to see that the Coalition is already receiving recognition, most recently from the National Institutes of Health Office of Extramural Research.[50]

We strongly endorse those efforts and recommend that they receive the support they need to succeed. The university should strive where feasible[51] to break down this information by demographic group as well.

11. Promote and reward collaboration among biomedical faculty.

We are entering an era of team-based science. Numerous reports and articles in recent years have underscored the ways in which much of the future of science is likely to sit at the intersection of disciplines and emerge from the collision of ideas in a team.[52] And yet, the incentive structure of biomedical science is still built to no small degree on individual accomplishment: Federal funding remains largely structured around a principal investigator. Promotion and professional recognition are premised on individual accolades. Science is built on a winner-take-all system that can disfavor those who collaborate.[53]

Still, we are seeing the earliest signs that the system is changing, as research project grants increasingly are allocated to co-PIs, and more money than ever has shifted to program projects and research center grants or cooperative agreements that require team science and provide opportunities for junior faculty to be included. Examples are the NIH Director's Transformative Research Award, which specifically seeks out projects from collaborative investigative teams in addition to individual PIs,[54] and the National Institute of General Medical Sciences' new Collaborative Program Grant, which is "designed to support highly integrated research teams of three to six PD/PIs to address ambitious and challenging research questions that are important for the mission of NIGMS and are beyond the scope of one or two investigators."[55]

Our university already has a well-earned reputation as a place with an exceptionally strong culture of collaboration; its spirit of collegiality and willingness to help and support other researchers distinguishes it from other institutions. This culture is reflected in structures we have already put in place (for example, the Johns Hopkins and Kaiser Permanente Research Collaboration Committee),[56] and in recent grants awarded to our researchers (such as the American Heart Association Strategically

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50 National Institutes of Health, Open Mike, Two Years (or so) of "Open Mike", Dec. 29, 2017, available at https://nexus.od.nih.gov/all/2017/12/29/two-years-or-so-of-open-mike.

51 In particular, we should seek to do so if and where the information will be statistically useful and not infringe on the privacy of trainees. Such a breakdown would help assess whether there are differences in time to degree and career placement that are unique to trainees of a particular gender, race or ethnicity, or citizenship status, and that therefore require unique institutional responses.

52 National Academy of Sciences, *Enhancing the Effectiveness of Team Science* (2015); B. Uzzi et al., "Atypical Combinations and Scientific Impact," Science 342, no. 6157 (2013): 468–472; S. Wuchty, B.F. Jones, and B. Uzzi, "The Increasing Dominance of Teams in Production of Knowledge," *Science* 316 (2007): 1036–1038.

53 Arturo Casadevall and Ferric C. Fang, "Winner Takes All," Scientific American 307, no. 13 (2012); Arturo Casadevall and Ferric C. Fang, "Reforming Science: Methodological and Cultural Reforms," Infection and Immunity 80 no. 3 (March 2012): 891–896.

54 NIH Director's Transformative Research Awards, https://grants.nih.gov/grants/guide/rfa-files/RFA-RM-17-007.html.

55 Collaborative Program Grant for Multidisciplinary Teams (RM1), https://grants.nih.gov/grants/guide/pa-files/PAR-17-340.html.

56 Johns Hopkins and Kaiser Permanente Research Collaboration, https://jhkpresearch.johnshopkins.edu/.

Focused Research Network award, which requires collaboration both within the School of Medicine's Division of Cardiology and with awardees at other institutions).[57] Still, given the many ways the university is separated, to at least some extent, across geography, laboratory, and discipline, potential collaborations fall through those gaps. We need to do more to facilitate team-based biomedical research, consistent with funding priorities from national funders.

For these reasons, the Committee recommends that the university build platforms to promote collaboration across its scientists and schools. The Committee points to three particular areas of promise here.

First is technology: The university should invest in a searchable database that would allow new scientists to find potential collaborators in other laboratories, schools, and campuses. The Provost's Office is currently developing a faculty database—we endorse this effort, and recommend that it include the capacity to allow searches of faculty research interests, publications, and grants, and identify for faculty prospective areas of collaboration and other topics of interest. Other universities have started to develop dynamic tools in this regard, and Johns Hopkins should support a first-in-class option.

Second is mentoring and grants: As funding pressures continue to grow, time that the principal investigator would otherwise spend on training and mentoring is often diverted to grant writing or regulatory compliance. In our discussions with faculty at Johns Hopkins, the comments about faculty mentorship were largely positive. And yet, concern surfaced here as well that funding and clinical imperatives may be pulling investigators away from mentoring responsibilities. At the same time, early indications suggest that junior faculty may be finding it more difficult to gain traction in a world that is easing toward larger and collaborative, team-based grants.[58]

As a consequence, the Committee recommends that the Provost's Office create a pilot program to offer incentives for senior investigators to include junior faculty on grant applications as co-principal investigators or co-investigators. A program of this sort could help solve two problems at once: First, it would help formally fuse a collaborative mentorship relationship. Second, it would provide a financial safety net for boost to early career investigators at a moment of funding austerity.

Third is personal interaction: The university has had experience with programs that are designed to connect researchers from across the university in new ways, such as research matchmaking events (organized by the Department of Pathology) and Belgian beer events (organized by the Science of Learning Initiative). These programs have drawn raves, with faculty describing their delight at having discovered potential collaborators they had not even known about on another campus, and new research initiatives emerging from these events. The university should take steps to multiply these

57 American Heart Association's Strategically Focused Research Networks General Application Information, https://professional.heart.org/professional/ResearchPrograms/StrategicallyFocusedResearchPrograms/UCM_494568_Strategically-Focused-Research-Networks---General-Application-Information.jsp#programstructure.

58 M.F. Charette et al., "Shifting Demographics among Research Project Grant Awardees at the National Heart, Lung, and Blood Institute (NHLBI)," *PLoS ONE* 11, no. 12 (2016), e0168511; Robin Barr, National Institute on Aging, R01 Teams and Grantee Age Trends in Grant Funding, April 22, 2015, https://www.nia.nih.gov/research/blog/2015/04/r01-teams-and-grantee-age-trends-grant-funding.

programs, and experiment with new approaches, so they are broadened to involve more disciplines and become a regular feature of university life, the rule rather than the exception.

12. Establish a Research Core Coordinating Committee to provide oversight and coordination of research core activities and policies.

In today's funding climate, the services and equipment offered by the university's more than 100 cores are not just beneficial but essential to meeting our biomedical scientists' research needs. Without well-equipped cores and their highly skilled staff, our scientists would not be able to perform the cutting-edge research that has led to real breakthroughs. The Committee found, however, that the university's current diffusion of cores also presents challenges. Specifically, the operations of our cores are for the most part uncoordinated, leading to duplication in services, cannibalization of business, and an inefficient and deeply suboptimal allocation of resources and equipment.[59]

The university has made significant advances in how we support and provide access to cores and associated infrastructure in the last several years. Johns Hopkins Medicine has developed Core in a Box,[60] which provides the Johns Hopkins research community with resources for successfully setting up and maintaining a core. And since 2011, we have brought nearly half our cores onto the iLab online platform,[61] which assists our scientists in navigating the array of resources available to them through cores, and enables them to make and manage service requests and equipment reservations for multiple cores all through one consolidated portal.

Even so, the Committee found that there remains a need to examine broadly how the university allocates biomedical research resources, to identify ways to recover costs and then reinvest in targeted efforts identified in this report (e.g., Recommendations 13 and 15 below). There is also a specific need for greater strategic planning around cores and the policies underlying how they are resourced and used.[62] Therefore, the Committee recommends that the university create a Research Core Coordinating Committee, or RCCC, composed of faculty, staff, and administrators from across the divisions.

Numerous models for this coordinating function exist at peer universities. For instance, the University of California, San Francisco, established a Research Resource Program in 2010 to oversee its approximately 80 cores. This program has launched a strategic plan to invest in emerging technologies, coordinate core space and activities, strengthen financial management of cores, provide support for core staff and new researchers, and promote the availability of core facilities.[63] Other successful

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59 For instance, it is not atypical for multiple groups at the university to have particular pieces of expensive equipment that are not running at capacity.

60 Johns Hopkins Medicine, Core in a Box, http://www.hopkinsmedicine.org/research/resources/synergy/core-in-a-box/.

61 Johns Hopkins University, Search JHU Core Facilities, https://johnshopkins.corefacilities.org/landing/42#/search.

62 An example of good coordination is the proposed Zeiss Center of Excellence, which will house new microscopy technology at a core facility. By locating multiple pieces of new microscopy equipment at one core rather than multiple labs or cores, the university was able to solicit competitive bids from equipment vendors and achieve economies of scale.

63 The UC San Francisco model was then replicated at UC Davis for its over 170 cores.

models include the University of Chicago's Office of Shared Research Facilities[64] and the Office of Collaborative Science at NYU's Langone Medical Center.[65] Johns Hopkins already has localized models for this type of strategic collaboration with cores, through initiatives like the Integrated Imaging Center, which coordinates provision of imaging, microscopy, and microanalysis services to scientists across Hopkins divisions and at other universities as well.[66]

Among the areas of inefficiency and vulnerability that the Committee recommends the RCCC address early in its work are:

- **The creation of new core facilities.** There is now little to no oversight governing the creation of new core facilities. As a result, new core facilities are coming online that may be duplicating the services of existing cores or are not responsive to demand, leading to unnecessary duplication in services, equipment, and administrative support, and as a result, more expensive and less effective science. The Committee recommends that the RCCC develop a set of policies surrounding when and how new cores should be formed.
- **Tracking core facility resources.** The university currently lacks the ability to centrally track core facility assets, like key instrumentation, across cores. This is now an area of such deficiency that equipment vendors often have better information than the university itself regarding how many pieces of equipment are being purchased by our university's cores. core assets currently underway, but they would be greatly facilitated by technology that allows for real-time tracking.[67] The Committee recommends that the RCCC track, either through a software solution that can interface with iLab or through other means, purchase requests for certain core facilities assets across the entire university, so that duplication in procuring equipment is minimized.
- **Metrics for the performance of cores.** The RCCC will allow for strategic decision making about how best to support certain cores, restructure others, and even perhaps reward star performers.[68] Critically, no single metric should be dispositive on its own; for instance, some core facilities, no matter how well managed, will run deficits, given the cost of the specialized instrumentation they house versus the research volume they can sustain. These facilities nonetheless provide critical services to

64 The University of Chicago, Office of Shared Research Facilities, https://osrf.uchicago.edu.

65 NYU Langone Health, Division of Advanced Research Technologies, https://med.nyu.edu/research/scientific-cores-shared-resources/division-advanced-research-technologies. See T. Winner et al., "NYULMC Office of Collaborative Science Cores—Enabling Personalized Medicine through Translational Research," *Journal of Biomolecular Techniques: JBT* 22 Suppl (2011), S33–S34, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3186589/

66 Johns Hopkins University Integrated Imaging Center, http://pages.jh.edu/~iic/index.html.

67 As a general practice within the School of Medicine, the SOM Business Office contacts the Office for Faculty Research Resources when anyone in the SOM makes a purchase request for equipment costing $200,000 or more. The Office for Faculty Research Resources then consults a fixed assets inventory report to determine whether to approve the request, in order to avoid duplication/competition. This report covers only SOM assets, however, and not assets at other divisions. The Whiting School of Engineering undertakes asset tagging on major pieces of equipment but does not catalog them in a systematic manner. WSE is in the process of trying to set up a system that would help manage/track these assets (both existing and new incoming pieces of equipment).

68 These metrics might include user satisfaction (measured via surveys), research volume (measured via service logs), research impact (measured via publication citations), professional development of technical staff (measured via hours at trainings and conferences), and solvency (measured via balance sheets).

the university research community, without which it would be at a competitive disadvantage.[69]

- **Expansion of cores, proposals for shared instrumentation.** The RCCC would be able to perform a critical role in identifying both areas where new or strengthened core facilities are necessary and a strategic path forward to filling those gaps. For instance, it was the view of the Committee that core facilities at the university may be underdeveloped for clinical and population sciences, and that early career faculty in particular are unable to access the often highly expensive services in those areas where they do exist. On a related note, the Committee believes the RCCC should play a broader role in the coordination of shared instrumentation proposals, to strengthen those proposals and avoid needless duplication. (See also Recommendation 13.)
- **Authorship and acknowledgment.** There are no standard criteria at Johns Hopkins for acknowledging cores and their scientists in scholarly articles. The iLab platform provides guidance, but it is not widely followed.[70] As a result, the contributions of professional scientists often go unacknowledged, making it difficult for the institution to gauge cores' research impact, hindering review of these publications as a consideration for professional scientists' promotion, and contributing to a view on the part of core staff that they are undervalued as part of the research enterprise. This lack of acknowledgment was raised repeatedly as a concern by the professional scientists with whom the Committee spoke. A clear set of policies on core facility personnel authorship and acknowledgment would be consistent with NIH guidance, journal rules, and the practice of peers.[71]

13. Promote the acquisition of key biomedical instrumentation on a shared basis.

When instrumentation sits in one researcher's lab rather than a core, the return on its investment is diminished because it experiences longer periods of idle time, whereas at a core it can be reserved for use by a different researcher as soon as one researcher no longer needs it. This underutilization extends to the staff supporting instrumentation: When staff with expertise on particular equipment are siloed to one lab, they may lack opportunities to offer their skills elsewhere at the university. The distributed purchase of instrumentation by individual labs can also lead to needless duplication and waste. Also, one of the many advantages of core facilities is their capacity to facilitate collaboration, since each core can see the multiple experiments researchers are conducting using its instrumentation, and use that knowledge

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69 Conversely, cores that can stay solvent currently lack an incentive to do so—no supplemental funds are awarded to these cores for strong financial management and no bonuses are given to their directors—so there are efficiency gains to be made from tracking and rewarding good core management.

70 Specifically, the iLab Core Finder page has this exhortation: "Authorship: If core personnel provide significant intellectual input to the results submitted for publication, then it is reasonable and appropriate to include them as co-authors. Since circumstances vary greatly, the Association of Biomolecular Resource Facilities provides recommended guidelines for authorship on manuscripts," http://www.hopkinsmedicine.org/research/resources/synergy/core-in-a-box/finder/index.html.

71 University of Michigan, Office of Research, Biomedical Research Core Facilities Authorship & Acknowledgment Policies, https://research.medicine.umich.edu/office-research/biomedical-esearch-core-facilities/brcf-authorship-acknowledgement-policies. See also NIH Office of Intramural Research, Research Cases for Use by the NIH Community, Collaborative Science and Authorship, 2015. "A critical dimension of successful collaborative science related to clear roles and responsibilities concerns planning for future publication(s) with the fair and appropriate allocation of credit through authorship. Written authorship agreements that reflect the substantive contributions of all the research staff and laboratories involved in the project, including students, technicians, fellows, and investigators (including in core facilities and with extramural partners), are especially important in the context of multi-team research." See also the Association of Biomolecular Research Facilities authorship guidelines, https://abrf.org/authorship-guidelines.

to connect researchers with common inquiries together, spurring new discoveries. This potential for collaboration is lost when researchers buy instrumentation only for themselves.

Therefore, the Committee recommends that the university develop initiatives that will incentivize researchers to place instrumentation in cores. The Committee believes the RCCC should play a central coordinating and policy role in this endeavor. There are a number of possible avenues here that are worthy of consideration, but one approach is to develop an instrumentation fund that could only be used for instrumentation to be housed in a core. The University of Southern California, for example, has a Core Instrumentation Fund that supports the purchase of instrumentation costing up to $300,000 on the condition that it is made available to the entire university community through a core.[72] Applicants to the fund must demonstrate that the instrumentation's user base would span multiple schools, and must commit to ongoing support and maintenance of the instrumentation as a condition of the award.[73]

Another area where the university could play a stronger role in promoting the collaborative pooling of resources is in the purchase of shared instrumentation grants. The NIH's shared instrumentation grant program enables NIH-supported investigators to purchase or upgrade a single item of "expensive, specialized, commercially available instruments or integrated systems that cost at least $50,000," with a maximum award of $600,000.[74] While institutional matching is not required in order to obtain a SIG, the NIH indicates that it is expected: "[C]ommitment of an appropriate level of institutional support, to ensure the associated sustaining infrastructure, is expected and should be described."[75] NSF and DOD also operate similar shared instrumentation grant programs.

Johns Hopkins has a solid success rate in obtaining shared instrumentation grants, but the Committee believes it could improve its prospects with better matching. The Committee recommends that the university launch a shared instrumentation grant matching fund that would provide support based on a tiered formula that considers the expected user base of the instrumentation (both size and span across departments and divisions) and the size of the department seeking the grant. This matching fund could operate either as a stand-alone fund, as exists at some peers,[76] or as part of the fund described above to incentivize purchase of instrumentation for cores, as at the University of Southern California. The fund could be managed by the RCCC, which, in any case, should play a role in coordinating applications for shared instrumentation grants.

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72 USC Core Instrumentation Fund, https://research.usc.edu/for-investigators/funding/usc/instrumentation/; Request for Proposals USC Core Instrumentation Fund, https://research.usc.edu/files/2011/05/FY19-Core_Instrumentation-Fund-RFP-FINAL.pdf.

73 We recommend that the implementation of this recommendation exercise particular scrutiny over the economics of a proposal, so that this initiative does not promote the use of unrealistic business plans to secure instrumentation.

74 National Institutes of Health, Shared Instrumentation Grant (SIG) Program (S10), https://grants.nih.gov/grants/guide/pa-files/PAR-16-054.html.

75 *Ibid.*

76 UCSF has an Institutional Matching Instrumentation Award, supported centrally, that provides awards of up to $200,000 as matching funds for any source of extramural or internal funding used "to fund cutting-edge technologies that are accessible to all USCF researchers," and that are housed at a core facility. UCSF, "The Research Resource Program's Chancellor's Funds for Core Development Funds Seven Instrumentation Awards," May 30, 2017, http://rrp.ucsf.edu/news/research-resource-program%E2%80%99s-chancellor%E2%80%99s-funds-core-development-funds-seven-instrumentation-0 ; see https://rap.ucsf.edu/institutional-matching-instrumentation-award. The University of Wisconsin–Madison has a matching program specific to NSF-MRI program grants, which provides up to 20 percent of the total cost of the instrumentation to a limit of $750,000 UW-Madison Research, Grant Matching Programs, https://research.wisc.edu/funding/grant-matching-programs/.

More generally, the Committee recommends that the university work to find creative solutions to support our research technology and infrastructure in a financially sustainable way. The university is at some risk of falling behind in certain areas because it lacks the right equipment, and purchasing that equipment requires a multimillion-dollar investment that no one core, department, or division can finance on its own. The university is also facing near-term challenges with computing power, data storage capacity, and computational analytic support that are essential for modern biomedical research. Therefore, in addition to the specific recommendations above, the Committee believes the university, including through the RCCC, should undertake a strategic plan to identify untapped approaches to purchasing and renewing major shared equipment.

14. Strengthen the university's coordination with nonfederal entities for investment in biomedical research facilities.

Just as individual laboratories can better leverage their resources through core facilities, so can individual universities better leverage their resources through multientity research facilities.

There is every reason Johns Hopkins University should be at the forefront, in the mid-Atlantic region, of identifying opportunities for collaboration with state governments, private industry, foundations, and other universities on biomedical research facilities. In addition to leveraging scarce resources, such a move would allow Johns Hopkins to work with the state of Maryland and institutional partners to attract biomedical talent to the Baltimore region. This sort of collaboration could be particularly valuable in the current budget climate, where federal resources are uncertain.

Hopkins has developed experience in this vein with projects like the Maryland Advanced Research Computing Center, known as MARCC. A new generation of biomedical facilities in this same multistakeholder mold would be a boon for the university, and could also help jump-start the growth of its core services. As just one example, Northwestern University, the University of Chicago, and the University of Illinois at Chicago formed a groundbreaking core research facilities partnership, called the Chicago Biomedical Consortium, to provide open access to each other's cores at no additional charge.[77] Therefore, the Committee recommends that the mandate of the new RCCC specifically include recommending steps on how to improve Johns Hopkins University's coordination and partnerships with area research institutions on shared laboratory infrastructure. This could include steps to work with other university partners in the region to develop a version of MARCC for instrumentation.[78]

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77 Chicago Biomedical Consortium, https://www.chicagobiomedicalconsortium.org/. Another example is the recently completed Biomedical Sciences Partnership Building, or BSPB, in Phoenix, home to the University of Arizona College of Medicine's flow cytometry core. The project grew out of a collaboration of the city of Phoenix, the state university system, and private foundations, and was funded through $136 million in state construction bonds. The BSPB houses eight floors of laboratory space (six wet, two dry), spanning 245,000 square feet. See http://phoenixmed.arizona.edu/bspb, http://phoenixmed.arizona.edu/about-us/community-partners, http://phoenixmed.arizona.edu/news/regents-approve-new-ua-downtown-phoenix-project.

78 An example of this cross-university instrumentation sharing is the New York Structural Biology Center, founded in 1999 by nine New York research institutions, including Columbia University, New York University, Albert Einstein College of Medicine, and the City University of New York, to provide biomedical research instrumentation and services to commercial and academic clients, such as high throughput gene-to-structure determination, X-ray crystallography, and sophisticated microscopy. http://nysbc.org/.

15. Expand the Core Coins Program, and use this mechanism to strengthen support for junior faculty.

The Core Coins Program is a School of Medicine initiative designed to encourage investigators to access core services to support their research, by providing rapid, targeted funding of up to $25,000 directly to cores to address small but critical gaps in basic, clinical, and translational research work currently not funded by other sources.[79] Those funds are then distributed to investigators according to criteria that might include, for example, funding for junior faculty who need help establishing a laboratory early in their careers, or faculty who need to generate preliminary data to strengthen a grant application. The program is administered through iLabs; thus, the funds can only be used at/by cores that are on the iLab platform, encouraging further core participation in iLab.

The program is on a pilot basis, with only a handful of coins distributed each year to School of Medicine cores. As more cores join the iLab platform, and as the university is better able to track core capacity and use, there is an opportunity to expand the use of core coins. The potential advantages of the program are many: By directing coins to cores that are sitting idle, the program can reduce inefficiency and save money. By drawing more investigators to cores, the coins can help generate the necessary scale and participation to grow and strengthen the core ecosystem across the university. And by allowing early career investigators to access shared expertise and resources that they might not be able to afford on their own as they seek to build a line of research at the outset of their careers, core coins also offer an effective and targeted tool to support our early career investigators.

For these reasons, the Committee recommends that the university invest in the expansion of the Core Coins Program across the university, with a particular eye to providing coins to junior and new faculty.

16. Review current promotion policies across the schools to ensure they reward innovation, collaboration, mentorship, and excellence in the various aspects of the JHU mission, including teaching, practice and service.

There is concern on the national stage that the academic promotion and tenure process may feature in many of the tensions identified in this report. Reports discuss how the incentive structures at universities may prioritize the amount of grant recovery or publication volume and venue rather than the quality or creativity of research, markers of individual success rather than team-based science and collaboration, academic work over research partnerships with industry and other non-academic partners, and building one's own portfolio rather than training and mentoring others.[80]

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79 SOM, Core Coins description, http://www.hopkinsmedicine.org research/resources/synergy/core-in-a-box/funding/index .html.

80 Arturo Casadevall and Ferric C. Fang, "Reforming Science: Methodological and Cultural Reforms," *Infection and Immunity* 80, no. 3 (March 2012), 891–896; National Institutes of Health, Physician-Scientist Workforce Working Group Report (2014); National Academies of Sciences, Engineering, and Medicine, *Promising Practices for Strengthening the Regional STEM Workforce Development Ecosystem* (2016).

As noted, faculty at Johns Hopkins go out of their way to identify the culture at Johns Hopkins as far more conducive to a spirit of innovation and collaboration than at other universities. These are highly complicated issues: Promotion and tenure decisions have a financial reality that cannot be avoided, and untangling the good from the bad in tenure policies is a delicate art. But the Committee notes that issues relating to promotion and tenure tend to rise to the top of the list as areas of concern in exit surveys, among others, of Johns Hopkins faculty. And though other universities have started to act in this space— through changes to promotion and tenure and also other faculty incentives[81]— Johns Hopkins has the opportunity to exercise leadership.

The Committee is conscious that it possessed neither the membership nor the breadth of expertise to address this issue itself. Therefore, it recommends to the president and the provost that they convene a follow-on task force of academic leaders and faculty to consider our promotion policies in the biomedical sciences, review the practices at other universities, and set out principles and recommendations for the reform or refinement of those policies at the university, to ensure they advance the objectives, principles, and recommendations in this report.

81 One approach to encourage teaching excellence is through named professorships for outstanding teachers. A version of this approach is taken by the University of Michigan, which awards Distinguished University Professorships to professors exhibiting superior teaching skills. Each professorship bears a name determined by the appointive professor in consultation with her or his dean, and carries an annual salary supplement of $5,000 and an annual research supplement of $5,000. See Top U-M Faculty Recognized for Teaching, Scholarship, http://www.ur.umich.edu/0910/Oct05_09/00.php; Distinguished University Professorships, http://spg.umich.edu/policy/201.91.

Part Three:
Funding and Resources

Johns Hopkins University receives more federal research funding each year than any other university in the nation. The university has led the National Science Foundation's total research expenditure rankings each year since 1979. And with regard to National Institutes of Health research funding in particular, the university once again led the nation. In fiscal year 2016, Johns Hopkins received 1,297 awards for $651 million, outpacing the next university on the list by $73 million. These achievements in the pursuit of competitive, merit-based, and peer-review grants are a testament to the ingenuity and talent of our scientists.

And yet, the funding landscape is shifting beneath our feet. Federal research funding has declined nearly 20 percent in real dollars over the past decade, a tectonic shift in the biomedical research endeavor that reverberates across the landscape and the scientists who operate within it. The massive shifts place an especially heavy burden on early career faculty, who, research shows, are especially vulnerable to funding changes. And this is especially true of universities like ours that are heavily dependent on federal research funds. Even within the corpus of funds that are available, the funding priorities of federal agencies are changing toward team-based science. Our university must adapt to this new landscape, and indeed, wholly aside from changes at the federal level, continually assess how best to provide the strongest possible support for our scientists' endeavors.

The recommendations that follow propose reforms to do just that. The Committee recognizes that the university is already considering or mindful of many of these recommendations, and that still others are long-term initiatives that will require a philanthropic investment. The recommendations are nonetheless offered here as a roadmap for the university to use to continue to strengthen its legacy as a national and global leader in biomedical innovation.

17. Continue and consider expanding the Catalyst and Discovery awards.

The federal government is at a moment of retrenchment in the area of federal research. NIH funding has declined by nearly 20 percent in real dollars in the last decade, and early career faculty face particular vulnerabilities. The age to first R01 for PhDs has increased from 39.3 in 1990 to 44.2 today. Johns Hopkins faculty have unusually high success rates across the board compared to those at other institutions, but even our faculty are not immune to these trends. The age to first R01 has increased at our university as well in recent years, and our early career faculty actually have lower success rates than our faculty between the ages of 45 and 60, a trend that is not reflected in the national data, suggesting that there may be a need to focus on our early career faculty.

The university has acted, launching in 2015 the Catalyst and Discovery awards programs. These programs, reflecting a $15 million investment, provide in the case of the Catalyst Awards up to $75,000 (as well as mentoring and peer networking opportunities) to support the promising endeavors of early career faculty, and in the case of the Discovery Awards between $100,000 and $150,000 for cross-divisional teams for new research collaborations. More than 100 Catalyst Awards and 70 Discovery Awards have been distributed, to date, but these programs are set to expire after this year. Faculty we talked to identified these awards by name, citing the commitment they represent to the professoriate at a moment of historic vulnerability, and the freedom they provide to pursue creative ideas that may not easily attract external funding. We recommend that the university renew and consider expanding the Catalyst and Discovery awards.

18. Initiate a new Bridge Award to retain high-performing faculty targeted to vulnerable periods in their careers.

We also recommend that the university launch a new award that is tailored to a distinct but related problem: the need for temporary support during gaps in extramural funding. The lower grant success rate in recent years has meant that faculty are stretched thin across research support. And the exceptionally low success rate for the original submission of new R01 or equivalent applications—between 8 and 12 percent—means the vast majority of applicants, even eventually successful ones, will need to resubmit. This is a moment when nimble and targeted funding to successful faculty who experience gaps in funding is critically valuable.

The university usually provides gap or bridge funding through a discretionary and ad hoc process at the department level. The Johns Hopkins Institute for Basic Biomedical Sciences has offered a more formal peer-reviewed bridge funding mechanism for basic scientists at the university for a number of years. And they report that nearly all basic science faculty who have received the funds have raised the external support they needed within eight months of the award. By contrast, Massachusetts General Hospital has taken a different approach for the past decade, providing “formulaic” gap funds to nearly any faculty member who fails to obtain an R01 or R21 but receives a score at or equal to the 20th percentile. MGH reports a return on investment of 15:1 on these grants.

The Committee recommends that the university pilot a similar mechanism available to all biomedical faculty, to sit alongside the Catalyst and Discovery awards but to be targeted at helping high-performing faculty through vulnerable periods, when a new faculty member is trying to obtain their elusive first independent research grant, or when a loss of funding could lead to the closing of an otherwise successful research laboratory or trigger a search for alternative employment or career trajectory. This program should be implemented in a manner that is mindful of the disparities in early career funding for women and other underrepresented groups[82] Unlike the Catalyst and Discovery awards, a Bridge Award program would need to be fluid, with applicants allowed throughout the year and prompt responses from the Provost's Office.

19. Expand shared resources for administrative and research support for the preparation and execution of grants.

A concern expressed by many faculty across the university was that they felt undersupported in establishing and operating their research projects. While research administrators are highly competent and committed, in many instances they find themselves stretched too thin and are under resourced. Faculty cited a need for stronger support in a range of activities, from grant preparation, to purchase orders, to IRB applications, to the hiring of staff, and they noted that the current state of support has led to inefficiencies, costly delays, and less time available for actual research endeavors. One faculty member put it this way: There's "a lot of back-end admin stuff that falls on your shoulders and takes away from days of work. So I think that's a big kind of hurdle to success." Another suggested these issues could lead faculty to move to industry, where this support is far more robust.

The university has made significant strides in recent years, among them the launch of a university Research Development Team, which assists project teams with cradle-to-grave proposal preparation and other pre-award needs[83] Even so, more can and should be explored in this space. Therefore, the Committee recommends that the university develop a more deliberate set of resources for research and clinical support on a shared or pooled model to improve research efficiency. These resources would allow faculty to do their work more efficiently and spend more time on their research or clinical work than on administrative tasks, and would help faculty at the outset of their career start a new lab when they are cash-strapped and would benefit most from easily accessible, pooled resources.[84]

20. Establish a Biomedical Enterprise Innovation Fund to promote experimentation in the functioning of our biomedical research enterprise.

The biomedical research enterprise is a complex ecosystem, one that defies easy or categorical answers. The Committee believes that some of the most valuable contributions to the future of the biomedical workforce are likely to emerge in no small measure from the same traditions of innovation, experimentation, and data-driven assessment that define the very science these efforts would seek to support. Johns Hopkins University is home to remarkable examples of organic innovation in this space.

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82 Robert Sege, Linley Nykiel-Bub, and Sabrina Selk, "Sex Differences in Institutional Support for Junior Biomedical Researchers," *JAMA* 314, no. 11 (2015): 1175–1177. This study finds that junior male biomedical scientists secure median startup packages from their institutions that are significantly higher than those of their female peers: $889,000 versus $350,000 for women.

83 JHU RDT, https://research.jhu.edu/rdt/about/.

84 Janice Clements: The SOM Joy in Medicine Committee is making strong recommendations for such pooled resources for both research and clinical work – a footnote could reference the JIM Taskforce Report and Recommendations (October 2017).

Examples abound:

- The Johns Hopkins-MedImmune Scholars program, a first-of-its-kind in the U.S. PhD training program between a major university and a biopharmaceutical company, exposes its participants to research experience in an industry environment, enabling them to build relevant career skills. The program also offers an optional yearlong practicum at MedImmune after the completion of the doctorate.[85]
- The Center for Innovation in Graduate Biomedical Education and the Department of Molecular Biology and Genetics are launching XDBio, a new cross-disciplinary biosciences PhD program that will include as one of its primary goals an accelerated time to independence.
- The Department of Molecular Microbiology and Immunology at the Bloomberg School of Public Health has led a newly launched R3 Graduate Science Initiative that provides a completely new graduate curriculum built around rigor, reproducibility, and responsibility.[86]
- The OPTIONS program, described above, creates a new structured multiyear career development track to help trainees identify a career path and then develop skills and career training within that community.
- The Computational Biology Consulting Core enables even the smallest labs at Hopkins to run state-of-the-art computational functions—for example, sophisticated genome analysis and RNA sequencing—on high-performance computers with the assistance of highly trained analysts.[87]

We should be seeking to hardwire this culture of innovation into the very backbone of the biomedical research ecosystem at the university, creating platforms to make it as easy as possible for new models for training, research, and laboratory organization to surface, be tested on a pilot basis, and if successful take root as permanent parts of the university and spread to other divisions as appropriate.[88] For these reasons, the Committee recommends that the university create a new Biomedical Enterprise Innovation Fund to seed new, evidence-based approaches to address some of the thorniest issues affecting the biomedical workforce: from new models to graduate education that seek to reduce time to degree.[89] to new models for postdoctoral training, to a shift to reliance on core facilities or professional scientist positions, to changes in the structure of laboratory staffing. The fund will seek to nurture efforts by Johns Hopkins biomedical programs to develop bold new ways of facilitating rewarding biomedical research in the classroom, clinical, and laboratory settings.

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85 First Ph.D. Candidates Selected for Johns Hopkins-MedImmune Scholars Program, https://ventures.jhu.edu/first-candidates-selected-for-johns-hopkins-medimmune-scholars-program/.

86 Critically ‘Thinking Science’: The R3 Graduate Science Initiative, https://www.jhsph.edu/departments/w-harry-feinstone-department-of-molecular-microbiology-and-immunology/academics-and-degree-programs/R3-PhD-program/index.html.

87 Computational Biology Consulting Core, https://ccb.jhu.edu/cbcc/.

88 Furthermore, outside bodies increasingly expect us to do just that: Most notably the National Institute of General Medical Sciences, which is unveiling a new T32 training program for evidence-based practices to modernize biomedical graduate education and address conflicts in the incentive structure of the research enterprise.

89 Any such effort to reduce time to degree should be undertaken in a manner that is fully consistent with the university's pedagogical and training mission.

21. Make financial support for biomedical PhD students and postdoctoral fellowships a development priority.

Because the vast majority of biomedical trainees are funded on training and research grants, and the vast majority of grants are shorter than the average length of PhD and postdoctoral training periods, the threat of funding loss is always on the horizon. As one program director interviewed by the Committee put it: "The No. 1 problem I see for students is funding. No grant guarantees funding for five years." Meanwhile, a number of national bodies have voiced concern about the tension in the incentive structure of the research enterprise: Principal investigators depend on the relatively low-cost work of pre- and postdoctoral researchers, who waver uneasily between their roles as trainee and labor. There are those who believe that a great many of the issues with the biomedical research enterprise are entangled in these funding realities.

One of the ways to tease apart this Gordian knot is to provide independent funding for trainees; a separate, stable stream of financial support would break this dependency, freeing more research dollars for PIs and offering trainees the freedom to seek out independent research opportunities and career development.[90] Biomedical PhD students at the Johns Hopkins School of Medicine are funded by a combination of NIH training grants, individual fellowships, and departments or lab funds. Roughly a quarter of SOM graduate students' wages and stipends and 5 percent of postdoctoral researchers' wages and stipends are supported by institutional funds. A number of our peer institutions provide institutional funds for most of, or all, their students for the first 12 to 24 months, and target graduate students with multiyear fellowships.

One can see the glimmers of a move underway in the philanthropic world to provide greater support for biomedical trainees. One prominent, recent example was the $200 million—out of a $500 million gift—that was made available exclusively to support graduate students at the University of California, San Francisco's medicine, nursing, pharmacy, and dentistry professional schools.[91] The Committee recommends that the university cultivate donors, as well, to support biomedical trainees. The Committee understands that this effort would be a long-term development objective. But it is a place where targeted philanthropy could have a dramatic, system wide effect at easing many of the current tensions in the biomedical workforce.

22. Increase the guaranteed salary support for faculty engaged in biomedical research.

Research universities like Johns Hopkins have long relied on external financial support from federal agencies to fund their work, but now are operating in a period of funding austerity. Between FY 2003

90 It offers as well as an early example of what it means to manage research resources.

91 "UCSF receives historic $500 million gift," Jan. 17, 2017, https://psych.ucsf.edu/news/ucsf-receives-historic-500-million-gift. Vanderbilt recently received a $125 million gift for graduate student scholarships and a leadership institute. Liz Entman, "Bold $125 Million Investment Supports Landmark Graduate Student Scholarships and Leadership Institute," https://news.vanderbilt.edu/2017/10/02/bold-125-million-investment-supports-landmark-graduate-student-scholarships-and-leadership-institute/.

and 2015, the NIH, a prime funder of Johns Hopkins' biomedical research,[92] lost 22 percent of its capacity to fund research, due to budget cuts, sequestration, and inflationary losses.[93]

At the same time, more scientists have entered the biomedical research enterprise,[94] creating competition over fewer resources. These factors, when combined with increasing federal funding uncertainty—with threats to dramatic cuts to federal research dollars often looming on the horizon[95]—understandably put enormous pressure on faculty to secure steady grants, and force them to spend inordinate amounts of their time writing and revising grant applications rather than pursuing discovery. This is particularly the case at soft money institutions like ours, where in many biomedical departments a large portion of faculty salaries comes from research grants. All said, about 60 percent of our SOM basic science faculty receive more than half their salary from NIH grants alone.

The Committee recognizes that, despite the financial stress faced by the university, much has been done to provide additional funding lines to faculty, including through the Catalyst and Discovery grants. Even so, in multiple consultations with biomedical faculty at Johns Hopkins, the Committee heard variously the ways in which recent funding cuts led them to feel as if they were always just barely getting by; how this uncertainty can pull scientists toward small and incremental fundable projects and away from longer-term innovative high-impact science, how it can drain the satisfaction from research. The pressure to "self-fund" their job through grants is often top of mind for those in positions with relatively little guaranteed salary support. Johns Hopkins faculty are not alone in this situation; similar anxieties are heard in research universities across the nation, for the reasons mentioned above.

The Committee deliberated at some length about this question, which defies easy solutions. Complicating matters further is that each of the divisions at the university operates under its own unique budgetary reality, all with different lines of revenue and costs. Ultimately, the Committee takes the view that it is important to find ways to strengthen salary support for its biomedical faculty. The Committee notes that there are different models of salary support, both at different Hopkins divisions and at comparable peers. Biomedical faculty at the Krieger and Whiting schools, for example, in keeping with the practice at many peer undergraduate institutions, receive nine months of departmental salary support; this practice differs greatly from the School of Medicine, which, in keeping with the practice of many of its peers, generally provides no departmental salary support. On the other hand, some

92 Dennis O'Shea, "Johns Hopkins Leads U.S. Universities in Research Spending for 37th Consecutive Year," The Hub, Dec. 7, 2016, https://hub.jhu.edu/2016/12/07/research-spending-hopkins-nsf/.

93 FASEB, NIH Research Funding Trends, http://faseb.org/Science-Policy--Advocacy-and-Communications/Federal-Funding-Data/NIH-Research-Funding-Trends.aspx.

94 Scott Jaschik, "The Shrinking Ph.D. Job Market," *Inside Higher Ed* (April 4, 2016), https://www.insidehighered.com/news/2016/04/04/new-data-show-tightening-phd-job-market-across-disciplines. Shows that there were 12,504 life sciences PhDs awarded in 2014 compared to 8,813 in 2004.

95 Jeffrey Mervis, "Key Legislator Tells Trump Officials to Back Off on Proposed Overhead Spending Cap for NIH," *Science* (Oct. 25, 2017), http://www.sciencemag.org/news/2017/10/key-legislator-tells-trump-officials-back-proposed-overhead-spending-cap-nih.

medical schools, such as the University of Michigan, provide several months of departmental salary support. These models—and the institutional and market forces that enable them—should be actively explored, as should other approaches, such as variable bases of support tied to attained grants. The Committee recognizes that the university has a relatively small endowment, and that larger industry trends are placing academic medical centers under financial stress, and so the Committee views this in no small measure as a long-term question, and recommends that the university treat it as a philanthropic priority moving forward.

23. Include in the design of biomedical research and training facilities attention to spaces that promote interaction among trainees, faculty, and staff in different disciplines.

One important way to foster an improved trainee and faculty experience is to create spaces where people meet and interact and form a larger community. Too often, scientists sit in their own space or at a lab bench. Training, research, and social spaces that contribute to interaction among trainees, faculty, and staff in different disciplines could improve the training experience in a multitude of ways: promoting the collision of new ideas, improving satisfaction, facilitating interaction and exchange of trainees from diverse backgrounds, and enabling our trainees to envision a future career through interactions with a multitude of individuals from across the biomedical sciences, and not simply others in their lab or program. These informal interactions require a conscious strategy, including the organization of space.

Other universities are taking note and designing new buildings with these interactions in mind. University College London is currently constructing the Michael Uren Biomedical Engineering Research Hub, which will bring together over 500 biomedical engineers, clinicians, and scientists at different career stages to develop new and affordable medical technology. The new building incorporates a range of social spaces to encourage the exchange of ideas.[96] The Columbia University Medical Center just unveiled a new Education Center structured in large measure around informal spaces, many of them vertically linked, to create unstructured opportunities for collaboration.[98] Examples of such spaces already at Johns Hopkins include the FastForward building in East Baltimore and the Applied Physics Laboratory Intelligent Systems Center. Although Johns Hopkins' biomedical campuses will have their own unique needs, it is the recommendation of the Committee that attention be paid to the need for physical spaces for trainee interaction.

96 Andrew Scheuber, "New Biomedical Engineering Centre Gets Planning Green Light," http://www3.imperial.ac.uk/newsandeventspggrp/imperialcollege/newssummary/news_7-7-2015-16-53-13.

97 Designboom, "Vagelos Education Center by Diller Scofidio + rRenfro Nears Completion in New York," https://www.designboom.com/architecture/vagelos-education-center-diller-scofidio-and-renfro-columbia-university-new-york-07-29-2016/.

Conclusion

The nation is at an inflection point in the academic biomedical sciences. Given the range of recent advances in knowledge and technology, we are poised to transform medicine, public health, and society at large. And yet, to act fully on this potential, we need to face forthrightly a number of looming challenges with regard to how we approach biomedical science, in areas ranging from research support, to innovation, to collaboration, to reproducibility. There is deep concern about the environment the nation has created for the incoming generation of scientists, and the science they will produce. The federal government has retrenched in its support of biomedical research, and the federal-academic biomedical compact shows sign of fraying. Johns Hopkins was the first modern research university on U.S. soil, and the moment is ripe for it to be a leader in defining the next generation of biomedical training and research. But doing so will require oversight and diligence and a shared commitment as one university.

To this end, the Committee offers one final recommendation:

24. Identify a leader responsible for implementing these recommendations, and a cross-university body to provide oversight.

The Committee is of the view that the above recommendations and the issues they seek to address are sufficiently complex and important that they will require a focused and concerted effort to implement them. Therefore, the Committee recommends that the president and the provost appoint one or more people responsible for the implementation of these recommendations, including their budget, programmatic details, and any questions of enforcement. Ideally, the work of this leader, or set of leaders, will be guided by a cross-university advisory body with faculty, student, trainee, and staff representation from those divisions with a biomedical footprint.

Appendix A

Mandate of the Committee on the Biomedical Scientific Workforce

The United States' system of biomedical research has been a leading driver of discovery and innovation for over half of a century.

Its use, in particular, of competitive, peer reviewed grants to independent scientists across the nation has fueled the development of an unparalleled biomedical workforce both inside and outside the academy, one that has charted a path to the very horizons of scientific knowledge. Our model of scientific research is now the envy of the world.

There are, however, challenges emerging in that system, ones that are drawing considerable attention. As our community well knows, these challenges take a number of forms. To start, there has been a persistent decline in the purchasing power of NIH funding, affecting the entire scientific workforce. For early career biomedical investigators, the period between the conferral of doctoral degree and the receipt of independent research grants has widened. Observers also point to tightening opportunities for careers in academia, and a lack of well-developed pipelines for alternative careers in industry and other non-academic settings. For those who do obtain a faculty position, burdensome grant application and regulatory demands divert time and energy from their research. They must navigate mounting tension among research, teaching, and clinical responsibilities, and some observers cite a creeping conservatism in the science that receives grants in an age of budget austerity.

While there have been a number of different reports from government and the nonprofit sectors that have sought to address this issue, most of the recommendations to date have been focused on the role of NIH and less on the role that research universities – the institutions where the vast majority of our biomedical scientists either train or work – must play in the solution.

Johns Hopkins, in keeping with its role as the nation's first research university and the single largest recipient of federal research funding for several decades, has an indispensable role to play in not only engaging but leading the search for answers. The university's efforts in establishing start-up research funding and investing in programs focused on early career scientists—such as the Catalyst Awards, BCI and BME Edge, and reforms recommended by a recent working group on PhD and postdoctoral researcher career development—attest to our awareness of the need to address this issue. But these initiatives are not sufficient.

To this end, the university is launching a Committee on the Biomedical Scientific Workforce.

The Committee will be chaired by Dr. Pierre Coulombe and Dr. Wendy Post, and include representatives from the School of Medicine, the Whiting School of Engineering, the Bloomberg School of Public Health, the School of Nursing, the Krieger School of Arts and Sciences, and the Applied Physics Laboratory. The Committee will be charged with canvassing best practices at our university and beyond, identifying areas of need in our own approach, and setting out a blueprint for reform.

Although it will explore solutions to problems that are clearly national in scope, the Committee is expected to focus on the particular challenges and needs of the Johns Hopkins research community. In particular, the Committee is invited to consider and draw on the innovative practices and initiatives already underway in our schools and divisions. For example, the School of Medicine has created a standardized method by which a core facility can be successfully launched and maintained ("core-in-a-box" concept), is undertaking an assessment of the time to degree completion, and developing new models for graduate biomedical education that involve partnerships with outside stakeholders in order to cultivate diverse and pragmatic career skills. The Whiting School of Engineering has crafted rules regarding the duration of graduate education and postdoctoral positions. A number of divisions are advancing new career development and mentoring initiatives for doctoral students, postdoctoral fellows, and junior faculty.

This is a potentially sweeping topic, and it is understood that the Committee will not be able to give every issue the same attention. It may be prudent for the Committee to recommend topics for later consideration. And although it is charged with exploring reforms for the biomedical scientific workforce in the first instance, in light of the particular issues now facing that field, a number of the questions the Committee is likely to consider are not unique to that workforce. The Committee is invited to identify areas or ideas for reform that other fields across the university might want to consider in later study.

The work of the Committee may, in its discretion, include some or all of the following areas and topics:

- **Faculty (Early Career, Diversity Initiatives, Pressures and Incentives).**

The age at which investigators receive their first R01 has risen steadily over the last couple of decades, and the next generation of scientists is increasingly finding it difficult to secure a foothold in the academic biomedical workforce. The university recently launched new funding programs, such as the Catalyst and Frontier Awards, to support early career faculty. Are there additional programs that could be helpful to these faculty, for instance in areas such as grant writing or preliminary data? Can initiatives underway in our divisions serve as models for the rest of the university, such as the SOM Clinical Scientists Career Development Awards, or BSPH boot camps that help junior faculty with grant and manuscript writing?

The demographics of the nation's biomedical workforce still are not reflective of the nation's diversity. It is paramount that we create an environment that ensures the full participation of all students, faculty, and staff, and the recruitment and retention of women and underrepresented minorities, including into positions of leadership. A number of initiatives are actively underway in this area across the university. Are there any additional practices or services that should be adopted that are tailored specifically to the biomedical workforce?

Finally, multiple reports are shining a light on the ways in which our biomedical scientists are finding themselves under new and demanding pressures. The PhD workforce is grappling with lower funding levels, heightened competition for funding, and increasing regulatory burdens, all of which is inevitably influencing their careers and their science in potentially significant ways. And the physician-scientist workforce faces its own, in many respects unique, set of challenges, including a growing tension between research and clinical responsibilities, longer training and increased debt, the expanding demands of board certification. What steps can and should Johns Hopkins take to reshape these incentives and ease their pressures?

- **Laboratories (Core Facilities, Alternate Career Paths)**

As universities come to rely increasingly on shared or core resources, some observers have argued that additional investment is needed to ensure effective and efficient operations of the cores. Some have also suggested that core facilities could over time become a sustainable platform for staff scientists who wish to participate in academic research, or that stronger cores could improve the efficiency of laboratories. Are there opportunities for improvement of core facilities at our university? What lessons, if any, should we draw from peer universities that have established formalized job descriptions and promotion policies for core directors and personnel, and dedicated professional leadership for cores?

The model of staffing a laboratory predominantly with graduate students and postgraduate trainees, with a relatively small number of more senior scientists who maintain employment over longer periods, has its virtues (e.g., the introduction of new ideas and perspectives into the laboratory) and its vices (e.g., near constant workforce onboarding). Concerns have been raised about its effect on the pipeline for the biomedical workforce. Are there opportunities for greater reliance on staff scientists, especially for the oversight and operation of laboratory investigation or scientific core services within the organization? What would be the effect of this model on the work of the laboratories? On trainees?

- **Students and Trainees (Graduate Education, Postdoctoral Fellowships, Career Development)**

One of the oft-cited causes of the delay in independent research for early career investigators is the gradual rise in the age at which they complete their education. At the same time, some voice concern that graduate education for the biomedical workforce is designed to prepare students for an all too narrow band of potential careers. Are there new steps the university should consider to promote desired outcomes in MD, PhD and MD/PhD programs? Should other models for graduate education be considered – for example, European and Scandinavian models that place more emphasis on research and less on coursework, and that take less time to complete?

The postdoctoral landscape has also changed considerably in recent years. National reports have expressed concern about the duration and other aspects of the postdoctoral training system in the biomedical sciences. At the same time, reliable information even about the number of postdoctoral fellows at most academic institutions, and in the country as a whole, is lacking, and the outcomes of postdoctoral fellows are poorly assessed. How should we assess postdoctoral fellows and programs? What are the outcomes that we should strive for with regard to postdoctoral training? Are there opportunities to improve the way in which we approach issues such as duration, mentoring, support, diversity, or opportunities for independent research?

Finally, the professional and career development function will be at the heart of the university's efforts to support the next generation of the biomedical workforce. A core effort is underway to build stronger core support of such services at the university through the implementation of the report of the PhD and Postdoctoral Fellow Career and Professional Development Working Group, in addition to divisional efforts in the schools. As these efforts unfold, are there any additional practices that might be recommended in this regard specifically as to the biomedical workforce?

The Committee will be asked to complete its report no later than the end of the 2016-17 academic year.

Appendix B

Membership of the Committee on the Biomedical Scientific Workforce

- **Pierre Coulombe,** PhD, E.V. McCollum Professor and Chair, Department of Biochemistry & Molecular Biology, Bloomberg School of Public Health (Co-Chair)
- **Wendy Post,** MD, MS, Professor of Medicine, School of Medicine, and Professor of Epidemiology, Bloomberg School of Public Health (Co-Chair)
- **Joel Blankson,** MD, PhD, Associate Professor, Division of Infectious Diseases, School of Medicine
- **Arturo Casadevall,** MD, PhD, Bloomberg Distinguished Professor and Chair, W. Harry Feinstone Department of Molecular Microbiology & Immunology, Bloomberg School of Public Health
- **Xin Chen,** PhD, Associate Professor, Department of Biology, Krieger School of Arts and Sciences
- **Janice Clements,** PhD, Vice Dean of Faculty and Professor of Molecular and Comparative Pathobiology, School of Medicine
- **Janet DiPietro,** PhD, Vice Dean for Research and Faculty and Professor, Bloomberg School of Public Health
- **Peter Espenshade,** PhD, Associate Dean for Graduate Biomedical Education and Professor of Cell Biology, School of Medicine
- **Heather Kristjanson**, Senior Graduate Student in the Center for Functional Anatomy and Evolution, School of Medicine
- **Nancy Glass,** PhD, MPH, RN, FAAN, Independence Foundation Chair and Professor, School of Nursing, and Associate Director of the Johns Hopkins Center for Global Health, School of Nursing
- **Rachel Green,** PhD, Investigator at the Howard Hughes Medical Institute and Professor of Molecular Biology and Genetics, School of Medicine
- **Patricia Janak,** MD, PhD, Bloomberg Distinguished Professor, Department of Psychological and Brain Sciences, Krieger School of Arts and Sciences
- **David Mohr,** BA, Genetic Resources Core Facility High Throughput Sequencing Lab
- **Larry Akio Nagahara,** PhD, Associate Dean for Research and Research Professor, Whiting School of Engineering
- **Chiadi Ndumele,** MD, MHS, Robert E. Meyerhoff Assistant Professor, Department of Medicine, School of Medicine
- **Sezin Palmer,** MS, Mission Area Executive for National Health, Applied Physics Laboratory
- **Antony Rosen,** MD, MBChB, Vice Dean for Research, the Mary Betty Stevens Professor of Medicine, Cell Biology, and Pathology, and Chief of the Division of Rheumatology, School of Medicine
- **Dionna Williams,** Postdoctoral Research Fellow, Department of Molecular and Comparative Pathobiology, School of Medicine