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Special Edition
Women in Biotech

Introduction

This Special Edition of the *MIT Faculty Newsletter* describes an initiative to address persistent underrepresentation of women faculty as board members and founders of biotech start-ups. Lack of participation at this interface between the university and industry can deprive women faculty and women trainees of professional opportunities and deprive the public of benefitting from discoveries made in women faculty's labs. It could also prove costly to the region as it competes for talent to maintain its preeminence in biotechnology.

In three articles we describe: 1) How the initiative began and led to the founding of the Boston Biotech Working Group; 2) Data the group gathered to document the underrepresentation of women faculty and to serve as a baseline for tracking change; and 3) A program called the Future Founders Initiative designed to facilitate participation by women faculty interested in translating their discoveries.

We are grateful to the members of the Boston Biotech Working Group, the American Academy of Arts and Sciences, the Sloan Foundation, and members of the MIT administration for their support of this initiative. We particularly thank Professor and Vice President for Research, Maria Zuber, for her endorsement of the effort.

Sangeeta Bhatia, Nancy Hopkins, Susan Hockfield

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Comment from Maria Zuber, E. A. Griswold Professor of Geophysics and Vice President for Research

ONE OF THE THINGS I MOST ADMIRE about MIT is our willingness to look at ourselves in the mirror and acknowledge that we need to do better.

In 1999, MIT released "A Study on the Status of Women Faculty in Science at MIT," which quantified for the first time the disparity of resources and opportunities for female faculty members in comparison to their male colleagues. The study, rich in data, inspired policy changes that have improved equity and removed many obstacles for female faculty.

Those changes, which are a work-in-progress, have appreciably improved the campus academic environment. Significantly, however, those changes did not address the world outside of MIT – specifically, the breadth of professional opportunities available to many male faculty. A next step in the quest for true equity lies in the realm of entrepreneurship and commercialization.

Taking up that challenge, in 2019 three senior women faculty – Sangeeta Bhatia, Susan Hockfield, and Nancy Hopkins – created the Boston Biotech Working Group. Using data collection and analysis, the group set out to explore the opportunities available to female faculty in biotech entrepreneurship. They convened stakeholders from the academic, medical, biotech, and venture communities, and they investigated service on scientific advisory councils and boards, access to venture capitalist funding, and companies started.

Many of their findings, detailed in this issue, are instructive and indicate a path forward. But one of them – which identified 40 "missing companies" that would have been formed had our women been accorded the same encouragement and access accorded to the men – was a gut punch for me. MIT prides itself on being immersed in an innovation ecosystem that helps translate our ideas into action. Yet we are clearly underachieving, because we're not advancing all of the most promising results from our labs.

But at MIT, data is power. The data collected by the Boston Biotech Working Group are already leading to actions that may ultimately help build careers, drive economic growth, and even save lives. While this study focused on women, ongoing data collection extends to other underrepresented groups on the faculty, with the aim of maximizing the number of discoveries – made on the bench by *all* of us at MIT – that we get to the marketplace.

Origins of the Boston Biotech Working Group to Address the Underrepresentation of Women Faculty as Board Members and Founders of Biotech Start-ups

Nancy Hopkins

Introduction

MANY MIT FACULTY, PARTICULARLY IN Science and Engineering, engage in entrepreneurial activities. This includes founding companies and serving on their boards of directors or scientific advisory boards. In some fields these activities are an important part of faculty's professional life, because they provide exposure and access to cutting-edge technologies and information that benefit both faculty and their trainees.

Many reports have documented that, even today, women in STEM (science, technology, engineering, and mathematics) and other fields are often underrepresented in these activities relative to their numbers in the pipeline. Other studies have been conducted to understand why this is the case. While the reasons can be varied and context dependent, common findings point to lack of access to venture capital (VC) funding networks (1). This lack of access, and the consequent lack of participation, can pose at least a two-fold problem: it can deprive women faculty and women trainees of important professional opportunities, and it can prevent them from translating and commercializing their discoveries for public benefit.

In the mid 1990s, I chaired the first Committee on the Status of Women Faculty in Science at MIT, which addressed the marginalization and exclusion of women faculty *within* the university. In the course of that work, I received a mailing that listed 99 scientists from the Boston area who had been funded to start biotech companies. Remarkably, only one of the 99 people on the list, a professor at Harvard Medical School, was a woman. At the time, it was well beyond the ambit of our committee to address the underrepresentation of women at the interface of academia and industry, but in 1996 we produced an internal Committee Report to the Dean of Science in which we flagged the issue for attention (2).

Apparently, little changed over the next 15 years. In 2011, a woman from Harvard Business School reported to me that she had seen a list of 100 scientists in the Boston area funded by venture capital to start Biotech companies. Only one of 100 was a woman. The woman who reported this to me wanted to know how this was possible, given that by then, 50% of PhDs in Biology had long been awarded to women, and women comprised roughly 25% of university biology faculties (Table 1).

This woman's query prompted me to wonder how many women and men on the faculties of biology departments at MIT, Harvard, and comparable institutions had been involved with biotech start-ups as founders or board members. Using company data from the internet and discussions with faculty, I conducted a survey and found that it was rare for women faculty in biology not only to found biotech companies, but also to be invited to serve on their boards of directors (BODs) or even the scientific advisory boards (SABs) of companies founded by their male colleagues. This was true even though there were women on these faculties who were equally or more qualified scientifically than the men who had been asked to serve in these roles. My informal results (Table 2, next page) were described in 2013 in a *Nature* news article titled, "Barred from the boardroom" (3).

Preliminary Data Attracts Powerful Allies and Leads to the Boston Biotech Working Group

My informal survey results surprised our colleague Sangeeta Bhatia, a bioengineer and professor in MIT's School of Engineering (in EECS and IMES). An entrepreneur who has

CAREER STAGE	% WOMEN
Undergraduates	70%
PhD students	53%
Postdoctoral trainees	41%
Faculty	26%

Table 1. Percent women in Biology at MIT at different stages of career (2012).
[Data provided by Lydia Snover and Sonia Liou, Institutional Research, MIT]

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founded companies, and a person committed to supporting the careers of women in STEM, Bhatia promptly conducted her own informal survey of women on MIT's engineering faculty. She identified a number of them who had founded companies, but these women reported that they were seldom asked to co-found companies with male colleagues, and some perceived that it was more difficult for women to raise comparable start-up funding than for men. Importantly, when Ann Arvin, then the vice provost and dean of research at Stanford, conducted a similar study at Stanford, her findings were strikingly similar to ours (4).*

As important as they've been for raising awareness and explaining the problem, however, the publications I've mentioned above cannot *fix* the problem. The critical challenge is how to rapidly fix such an entrenched and still largely invisible problem at the interface of the university and private industry.

In September of 2018, I received a Lifetime Achievement award from Xconomy, a news and media company concerned with the biotech and tech industries – something of an irony, given that I had publicly brought the industry to task for the stunning lack of diversity in the leadership and governance of biotech start-up companies. I was introduced by Sangeeta Bhatia.

In my acceptance speech, I talked about my life in science and about the enormous progress I had seen for women faculty in

# of COMPANIES	INSTITUTION	# of MEN	# of WOMEN
13	MIT	145	4
2	Harvard	32	2
2	HMS	32	2
1	MSK	14	0
TOTAL: 18		**TOTAL: 223**	**TOTAL: 8**

Table 2. Representative data showing gender of the leadership of Biotech start-ups founded by MIT, Harvard, Harvard Medical School, and Sloan Kettering faculty.
Counts include founders (12 companies), BOD members (8 companies), SAB members (13 companies), and management (1 company). Data collected in 2013. 84 of the 231 people are full-time faculty.
Of 84 full-time faculty, 80 are men, 4 are women = 4.8%.

The data had obviously identified a pattern of professional barriers for MIT women faculty interested in translating their research discoveries and for women trainees, particularly in biological sciences. Some women faculty said they knew so little about commercialization that they were unable to advise graduate students and postdocs who expressed interest in biotech. A woman postdoc reported that the head of her lab gathered the male postdocs in his office at lunchtime for closed-door discussions about companies, while leaving the female postdocs sitting outside. Women faculty who had been interested in founding companies reported being unable to navigate the process on their own, even when it came to patenting their discoveries. A male colleague with experience in founding biotech start-ups pointed out that this inequity means that men on these faculties are earning much more than women. Faculty profits from commercialization are not infrequently in the many millions of dollars, and even serving on boards can double a faculty member's salary.

In November of 2017 I teamed up with my MIT colleague Harvey Lodish (Biology), who has extensive experience in founding biotech companies, to write an op-ed for the *Boston Globe* calling attention to this issue (5).

STEM thanks to MIT's efforts. I contrasted that change with what I perceived to be so little progress in diversifying the leadership in biotech, and I presented some of the data I had collected. Seated in the audience that night, at a table with Bhatia and me, was Susan Hockfield, MIT's president emerita. Immediately recognizing the implications of the data, Hockfield offered to join with us to devise solutions to achieve two goals: 1) increase the number of women faculty serving on boards of biotech start-ups; and 2) open avenues to commercialization for women faculty interested in founding companies. She made clear that she felt we needed to achieve both goals rapidly.

Boston has a robust VC industry, and MIT has a superb TLO (Technology and Licensing Office). Today, a typical MIT-founded biotech start-up gets its start when a discovery in an MIT lab is patented by the TLO and licensed to the start-up. One or two additional faculty, or a postdoc involved in the discovery, may also be co-founders. The boards of such companies typically include VCs, the faculty founder(s), and prominent scientists chosen by the VCs. SAB members are noted scientists in the field. We learned that when entrepreneurs found a company and create its BOD, they frequently draw on a network of venture capitalists and faculty, many of whom have founded multiple companies individually and together and almost all of

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*In the past few years, Arvin recently told us, women faculty in biology seem to be participating more actively in commercialization, (pers comm.).

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whom are men. As the industry has matured, moreover, faculty with experience in biotech have become more likely to be selected for these positions, making it even less likely for women faculty to participate.

Hockfield, Bhatia, and I assembled a list of experts and stakeholders to help us achieve our two goals. It included venture capitalists; faculty who had founded biotech companies; academic and hospital administrators; local and state officials; policymakers committed to fostering the biotech industry in Kendall Square, Boston, and across Massachusetts; members of the media; and the heads of MIT's TLO and Institutional Research (IR) offices. The leadership of the American Academy of Arts and Sciences also made the effort possible, by hosting a series of dinners for the group, which came to be known as the Boston Biotech Working Group (BBWG).

Data Collection, VC Engagement, and a Future Founders Initiative

BBWG dinners, the first held in December of 2018, were inspiring and quickly built momentum for action. The BBWG chartered a set of subgroups that were tasked to address different aspects of the problem. Progress has been rapid, with the initiation of several workstreams:

• The **Data group** secured a grant from the Sloan Foundation and hired a professor of entrepreneurism from Simmons Business School, Teresa Nelson, to identify all the boards served on and companies founded by all faculty in seven departments in MIT's Schools of Science and Engineering, drawing on public information and a faculty list provided by IR. That work, presented in the next article in this newsletter, documents the stunning lack of participation in commercialization by women faculty in biological sciences and the lack of inclusion of women faculty in Science and Engineering as co-founders and board members of biotech start-ups founded by male colleagues. It also provides a methodology and a baseline from which to measure change.

• **Heads of MIT's TLO and IR** had already partnered to collect data on the gender of faculty who file for patents, and on patents licensed to companies. This effort was strongly endorsed by Vice President for Research Maria Zuber, who also requested data on ethnic composition be recorded and reported to the MIT administration. These data should serve to raise awareness of the importance of the issue among faculty and VC biotech founders, and provide a baseline to track trends.

• The **VC group** agreed to promulgate among the VC community a pledge to aim for 25% women faculty on boards of their biotech start-ups by 2025, a percentage that reflects the percentage of women faculty in the pipeline. The group also proposed a fellowship program to bring women faculty into their firms for short-term VC experience, a proposal quickly endorsed and supported by Anantha Chandrakasan, MIT's Dean of Engineering, and Nergis Mavalvala, MIT's Dean of Science.

• The **Founder Development group**, led by Professor Bhatia, with Professor Lodish and with strong support from Dean Chandrakasan, launched the "Future Founders Initiative," described in the third article in this newsletter. Despite the pandemic, the Future Founders Initiative attracted over 500 participants to its fall 2020 bootcamp series.

• The **Media group** facilitated publication of articles in the *Boston Globe*, *STAT*, and the *Washington Post* describing the BBWG initiative and presentations at various regional, national, and international meetings (6).

• **Greater Boston Biohub and our regional advantage:** If more women faculty become founders and board members of biotech startups, we will not only address concerns about equitable participation but also create other benefits, among them maximizing this region's potential to drive innovation and healthcare interventions that will improve lives. As Susan Hockfield noted, "Consider the implications of one finding described in the article by the BBWG's Data group [the article that follows this one in this newsletter]: Even just in the seven departments analyzed in our study, the underrepresentation of women faculty as founders means that some 40 companies were not founded. Missing those 40 companies means missing the clinical interventions that could predict, prevent, and treat disease. Greater Boston hosts the most vibrant bio-hub in the world, but competition for that preeminent position is fierce. We owe it to the world at large to amplify our regional advantage by drawing on all of our talent to change the face of health and healthcare for the world."

Change hearts and minds or mandate outcomes?

So far, the BBWG's efforts have focused on data collection and on opening channels for participation by women faculty through the very exciting Future Founders Initiative and VC involvement. But two issues will require additional and distinct efforts, I believe. One is overcoming powerful unconscious biases and homophily (the tendency of people to work with people who look like themselves), the second is the issue of race and, specifically for us, the inclusion of women faculty of color in entrepreneurial activities.

As for unconscious biases, we have not yet designed remedies for the failure of male faculty to include female colleagues in their commercialization activities, nor for the greater difficulty for women faculty of raising comparable funds for start-ups, where many studies have shown that gender impacts funding

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levels. At the first dinner meeting of the BBWG, senior women faculty who had founded companies reported that they had been advised that if they wanted to be taken seriously when pitching to VCs, they should include their male students or postdocs, and have the men do "the pitch." Almost identical comments have come from women faculty at Stanford, Johns Hopkins, and other universities. These common experiences and the persistent underrepresentation of women faculty in leadership roles in biotech over 40 years have led me to ponder why progress for women faculty in leadership roles in STEM progressed more rapidly within academia than at this academia-industry interface.

Women gained entry to university faculties in the late 1960s and early 1970s thanks to civil rights and legal reform, and societal pressures led by women's groups. Titles VII and IX also drove change for women students and faculty once they had arrived: Universities were required to provide a level playing field for their students and faculty or risk losing their federal funding. A half century ago, equal opportunity became a legal requirement and a university ethic, with the goal being a diverse student body and faculty. But campus-based requirements and ethics do not apply in the biotech industry, where a more old-fashioned ethic of practice, sometimes called "the old boy network," still reigns. This poses a problem for MIT.

The biotech start-up industry relies on the university for its life blood. It, and the scientists who found companies and remain on the MIT faculty, are using the university's valuable resources – its brilliant faculty, students, and postdocs, its publicly funded research enterprise – to seed their business enterprises. By operating as they do, if not providing equal opportunity for women faculty and trainees, as well as for people of color, in this professionally important and potentially lucrative activity, they put the university at risk.

While it was clear from the BBWG dinners that every participant was anxious to fix these problems, we know how hard it is to change behavior and the underlying unconscious biases. Interestingly, the most radical fix suggested at our dinners came not from academics but from businessmen. One VC noted that the universities could fix this problem quite quickly. University endowments invest heavily in venture funds and could demand that the funds they invest in present evidence of diversity in the leadership of companies they found. Yale's legendary endowment manager, David Swensen, recently wrote that going forward he will have diversity on his mind when he invests, having been moved by the events around race in the past year, including George Floyd and the differential impact of the pandemic on people of color (7). One hopes his leadership will precipitate robust discussion of this approach.

At the first dinner meeting of the BBWG, senior women faculty who had founded companies reported that they had been advised that if they wanted to be taken seriously when pitching to VCs, they should include their male students or postdocs, and have the men do "the pitch."

As for women of color, the issues all women faculty encounter are usually compounded for them by the well-documented "double bind" at the intersection of race and gender. In terms of founders and board members of biotech start-ups, there is also the issue of pipeline to be considered both for female URMs ("underrepresented minorities," meaning American Indian or Alaskan Native, Black or African American, Hispanic/Latino, Native Hawaiian or Other Pacific Islander) and for other women of color.

Of the 675 faculty in MIT's Schools of Engineering and Science, only six are female URMs. (The 44 male faculty URMs in Science and Engineering represent only 6.5% of the STEM faculty.) These small numbers demand a different methodology to identify barriers and may also require additional approaches to facilitate participation (although it should be noted that all tenured female faculty URMs in Science and Engineering at MIT have participated in entrepreneurial activities). Clearly, it is important that such studies and efforts be undertaken. Our colleague, Helen Elaine Lee, suggested to me that given the small numbers at MIT, it would be desirable to extend the studies to male faculty URMs and to extend our studies of women faculty to specifically consider women of color in other leading research universities in Boston. As for facilitating participation, when numbers are low, recruiting even a few individuals to the leadership level can have an enormous impact by providing role models for trainees. Given the momentum of the group, now would seem a perfect time to do so.

Furthermore, gender inclusion and equity are inextricable from racial inclusion and equity, and a goal of the Future Founders Initiative going forward will be to help the biotech start-up industry reflect the full diversity of Boston's university faculties and of our society.

It had not occurred to me that in my retirement I would still be working on equity for women faculty. Initially, I was attracted by the opportunity to continue to work with Sangeeta Bhatia, whose passion for translating her discoveries through commercialization, and for furthering the careers of women in STEM, I find inspiring. When Susan Hockfield stepped forward and offered to help us, I agreed to continue our work. A problem as complex as the biotech issue can probably only be tackled pro-

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ductively by someone with Hockfield's experience and skill. I have been awed – yet again – by her leadership. It has been a unique pleasure, and a privilege to work with both Susan and Sangeeta. I thank them for this experience.

Acknowledgments
I thank Laurie McDonough for advice and her support of the BBWG, John Dowling for many discussions of these issues, Helen Elaine Lee for her insight about how to extend the efforts of the BBWG to faculty of color, Bob Buderi for valuable editorial advice, and Candida Brush for insights about entrepreneurism and venture funding.

References

(1) Many reports have documented underrepresentation of women in entrepreneurial activities in diverse fields, with some finding that less than 3% of venture funding goes to women nationally. Catalyst, the Kauffman Foundation, the Diana Project, and the EOS Foundation have consistently reported on these aspects of entrepreneurship. Further, many academic articles analyze the reasons why women may be underrepresented. See for example, Balachandra, L, et al. (2019) "Don't Pitch Like a Girl: How Gender Stereotypes Influence Investor Decisions." *Entrepreneurship, Theory and Practice,* Vol 43(I) 116-137.

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MIT Women and Men Faculty in Science and Engineering as Founders and Board Members of Companies in Science and Technology

A Report from the Data Group of the Boston Biotech Working Group

Introduction

AS PART OF THE BOSTON BIOTECH Working Group (BBWG) effort, a Data Group was established to better understand and track forward participation of women and men faculty members in the governance of science and technology companies. Many studies have documented significant underrepresentation of women faculty in these activities, including in biotech, but individual institutions involved in the BBWG are interested in establishing consistent methods and policies for gathering and reporting data on their faculty, and in obtaining public data to establish baselines to measure and compare changes over time and across various academic units.

Preliminary data gathered informally had already shown that women faculty in the biological sciences at MIT and Harvard participate in these activities much less frequently than male colleagues, and comparatively less than women faculty in some MIT engineering departments (Bhatia and Hopkins, unpublished). Importantly, a comprehensive Stanford University study using data from the university's Office of Technology and Licensing for engineering departments and Stanford's medical school and basic biology departments, had documented very similar differences (Hanes, et al. 2018). Our BBWG Data Group began by collecting comprehensive, up-to-date data for several departments in the Schools of Science and Engineering at MIT, thus establishing methodology as well as collecting baseline data for this institution. Funded by the Sloan Foundation and supported by MIT, this research project was launched in the summer of 2019. Below we present a report thereon.

The Research Project

Beginning with an official list of current MIT faculty, prepared by MIT's Office of Institutional Research (IR) for June 2019, a historical database was built from public sources of faculty member participation as for-profit business founders, board of director members and scientific advisory board members[1] in science and technology companies. The study encompasses faculty in seven MIT departments in the Schools of Science and Engineering.

[1] Outside Professional Activities forms (OPAs) were not used as a data source for this study as that information is a confidential personnel record available only to the Provost and a limited number of other individuals within MIT.

The goal of this study is to compare the commercialization activity of female and male faculty members, departments, and Schools (Science vs. Engineering), both currently and historically. Our results to date reveal variable rates of participation by women faculty in different departments and confirm a striking underrepresentation of women in Biology compared to their male peers, but they also show a greater participation by women faculty in some Engineering compared to Science departments.

Methodology

The sample for the study includes tenure-track, full-time faculty in seven of the 14 Science and Engineering departments: Biology, Chemistry, and Brain and Cognitive Sciences (School of Science) and Electrical Engineering and Computer Science, Biological Engineering, Chemical Engineering, and Materials Science (School of Engineering). We originally also included Physics, but it was dropped due to low relative commercialization activity. Data collection entailed searches of more than 35 publicly available data sources drawn from categories such as general business (e.g., Pitchbook, Capital IQ), specialized business press (e.g., Factiva, *Wall Street Journal*, Xconomy, MIT news sources), general internet searches, company websites, books, and professional information sources (e.g., CVs, LinkedIn). The work of data collection was conducted by a team of nine that included five undergraduate students, three PhD students, and one tenured faculty member, Professor Teresa Nelson, who has experience in the fields of science and technology innovation, women and gender, and organizational governance data collection. The team estimates their number of individual searches as greater than 15,000, including structured confirmation to test for reliability. Data analysis and interpretation was performed by Nelson and by MIT and Harvard faculty who work in relevant STEM fields, and with input from additional members of the BBWG. (See Appendix for expanded description of methodology.)

Select Findings

MIT has approximately 1,050 faculty members, of whom 250 are women (June 2019). Faculty hold appointments in departments that are housed in one of five Schools: Architecture, Engineering, Humanities, Science, or the Sloan School of Management.

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Business commercial activities can occur in all five Schools, but those of interest to the BBWG are centered in the Science and Engineering departments, so we focused our study on Biology, Brain and Cognitive Sciences, and Chemistry (School of Science) and Biological Engineering, Chemical Engineering, Electrical Engineering and Computer Science, and Materials Science (School of Engineering). The seven departments of study house 337 faculty members, of whom 73 (22%) are women.

1. Initial data analysis of seven Science and Engineering departments (see Table 1, page 14):

• *The total number of commercialization governance events (taking multiple participations per faculty member into account) is 1,042, including 243 board of directors memberships, 489 scientific advisory board memberships, and 310 founding events, resulting in 263 companies. (There are fewer companies than company founding events due to co-founding by MIT faculty.) Women faculty accounted for 93 of this total (9%), including 16 board of directors memberships, 53 scientific advisory board memberships, and 24 founding events, accounting for 24 companies.*

• *The percentage of male faculty members who have founded at least one company is 40% and that of women faculty members is 22%. The percentages of male faculty members who have served on a board of directors or scientific advisory board are 31% and 39%, respectively, and the corresponding figures for women faculty members are 14% and 30%.*

Striking observations that emerge from Table 1 are the variation in commercialization participation rates by female and male faculty in different departments, and the small fraction of faculty who are female in some departments.

Variable rates of participation could have multiple explanations, and small sample size might easily account for some variability. Most companies (85-90%) are founded by tenured faculty, so age and career-stage differences by sex and department were examined: Table 1 shows similar proportions of full professors across the departments studied. However, subfields even within a single department can have very different rates of commercialization, so the distribution of women vs. men in different subfields in each department requires attention by faculty with knowledge of the fields and individuals.

2. Further analysis of three departments: Biology, Biological Engineering, Chemical Engineering

To better understand the variable rates of participation, and because our group is particularly interested in biotechnology, we looked in more detail at Biology (School of Science), and Biological Engineering and Chemical Engineering (School of Engineering). Faculty in these departments have played an important role in the rise of the biotech industry in Kendall Square over the past 40 years, and male and female faculty in each department are sufficiently similar in age and likelihood of commercialization by field.

Biology Department

There are 58 faculty members in the department, of whom 14 are women (24%) (June 2019). The commercial-engagement activity of the Biology Department faculty is shown graphically in Figure 1 (page 15) and summarized graphically in Figure 2 (page 16), and numerically in Table 2 (page 14). The total number of "company founding events" do not represent a 1:1 correspondence with total number of founded companies, as some faculty members co-found companies with other MIT faculty members. Our data show that:

• 43% (N=19/44) of male faculty members founded companies while 14% (N=2/14) of female faculty members founded companies, for a total of 65 company founding events[2]: 63 by men, two by women.

• 65 company founding events by Biology faculty resulted in 55 companies founded by male faculty and two by female faculty.

• Of the 57 companies founded by Biology faculty, eight were co-founded[2] by 11 different members of the Biology faculty, and three from other MIT departments. All 14 of these faculty co-founders were male.

• 32% (N=14/44) of male faculty members served on 42 boards of directors (BODs), whereas one female faculty member served on one BOD.

• 55% (N=24/44) of male faculty members and 29% of female faculty members (N=4/14) served on at least one scientific advisory board (SAB). Five male faculty served on exactly one SAB, eight held 2-4 SAB positions, and 10 held 6-13 positions. One female faculty member served on one SAB, and three held 2-4 SAB positions. The 24 men served on 121 SABs, and the four women served on nine (Figure 2).

Figure 3, first panel (page 16) shows the five-year time intervals during which the 57 Biology Department companies were founded. We note the presence of the two female faculty founded companies in the last five-year period and discuss this fact further below.

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[2] Co-founding a company is considered a founding event in this analysis, and, therefore, discrepancies are expected between this number and the number of companies founded. This study does not consider co-founders who were not MIT faculty members.

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Biological Engineering and Chemical Engineering Departments
In contrast to Biology, the percentage of women faculty in the Chemical Engineering and Biological Engineering departments is lower (Table 1); however, the rates of commercialization governance engagement are higher.

Biological Engineering. This department has 26 faculty (N=5 women, N=21 men). Women faculty participate in commercialization activity at rates similar to male colleagues. The data show that:

• 52% (N=11/21) of male faculty members founded companies while 3/5 (60%) of female faculty members founded companies, for a total of 30 company founding events[2] that resulted in 29 companies: 24 companies were founded by male faculty, five were founded by female faculty.

• 38% (N=8/21) of male faculty members and 1/5 female faculty served on a board of directors.

• 57% (N=12/21) of male faculty members and 3/5 female faculty members served on at least one SAB. Four male faculty held one SAB position, five male faculty held 2-4 SAB positions, one held 5-15 SAB positions, and two held greater than 15 SAB positions. One female faculty member held one SAB position, and two held 2-4 SAB positions.

Of the 29 companies founded by faculty from this department, seven were co-founded by eight MIT faculty members (from this department and others). 8/8 co-founders were men. The five-year time intervals during which the 29 companies were founded is shown in the middle panel of Figure 3 (page 16).

Chemical Engineering. Chemical Engineering has 33 faculty (N=28 men, N=5 women). As shown in Table 1, most of the women faculty in this department are involved in commercialization, including founding companies. The data in Tables 1 and 2 and some data not shown reveal that:

• 36% (N=10/28) of male faculty members founded 64 companies while N=4/5 (80%) of female faculty members founded five companies, for a total of 76 company founding events[2].

• 36% (N=10/28) of male faculty members and N=3/5 (60%) of women faculty members served on a board of directors.

• 46% (N=13/28) of male faculty members and N=4/5 (80%) of women faculty members served on at least one SAB. Two male faculty held one SAB position, seven held 2-4 SAB positions, three held 5-10 SAB positions, and one other held more than 60 SAB positions. One female faculty member held one SAB position, and three held 2-4 SAB positions.

Nineteen companies were co-founded by Chemical Engineering faculty, none with a female MIT faculty member in any of the seven departments studied. The five-year time intervals during which all companies were founded is shown in the right-most panel of Figure 3 (page 16).

We conclude that women faculty in the Biological Engineering and Chemical Engineering departments commercialize at rates that are similar to male colleagues and have done so for many years.

Comparing across the three departments – Biology, Biological Engineering, and Chemical Engineering – shows that women faculty in the two Engineering departments (N=10) founded five times as many companies as women faculty in Biology (N=14), a result we discuss further below.

3. Outcomes of companies founded in the three departments
So far, our study has focused only on faculty participation rates as founders of start-up companies. An additional question of interest would be the types of companies founded and whether they differ between men and women faculty or between faculty in Science vs. Engineering. Biotech and other start-ups differ in the types of products or services they deliver. Companies may be small, medium, large, pubic, private, sustained, or short-lived, and in life sciences may span areas such as tools, medtech, diagnostics, digital health, and therapeutics. As such, there is no universal measure of impact. As a starting point we identified key governance-transition events: going public, being acquired by another company, receiving venture-capital investment, and closure[3]. By these relatively simple metrics, we observed a high level of success among companies founded by MIT faculty. The results for the three departments are as follows:

Biology
As of 2019, 19 of the companies founded by Biology faculty have been acquired (33%), 20 went public (35%), and 11 (19%) have closed. 44 of the 57 companies (77%) received at least $1 million in venture capital, with 27 of 57 (47%) receiving more than $50 million. Both female-founded companies are private, and one has received more than $50 million in venture-capital investment.

Biological Engineering
As of 2019, four companies have been acquired (14%), five went public (17%), and six (21%) have closed. 24 of 29 companies (83%) received at least $1 million in venture-capital funding,

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[3] The "closed" category includes firms that dissolved their corporate status (or had it dissolved by a Secretary of State), those filing for Chapter 7 or 11 bankruptcy followed by dissolution, those following an assignment of benefit of creditors (i.e., ABC) protocol, or those who sold assets under distress to another company as part of a close-out process.

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with 11 of 29 (38%) receiving more than $50 million. One company founded by a female faculty member was acquired, and three companies founded by women received more than $50 million each in venture capital investment.

Chemical Engineering
As of 2019, 21 companies have been acquired (30%), 19 went public (27%), and nine (13%) have closed. 49 of 69 (71%) received at least $1 million in venture-capital funding, with 29 of 69 (42%) receiving more than $50 million. All five female-founded companies are currently active, two having received more than $1 million in venture-capital investment.

4. 40 "missing companies": The impact of variable rates of company founding by women and men faculty in the seven departments analyzed to date
Although we have not yet studied all seven departments as carefully as the three described above, we did a simple calculation to ask how many additional companies would have been founded if the same fraction of women as men faculty in each department had founded companies, and if each had founded the same average number of companies as male-founder colleagues. The answer is that roughly 40 additional companies, mostly biotech and some tech, would have been founded.

5. Limitations
Our current study's department-centric approach means that we have excluded faculty, perhaps many, who are or have contributed to the innovation ecosystem of biotechnology, since many faculty across disciplines at MIT engage in health-related research. It means we have included faculty who are members of the departments studied whose work may not be biotechnology-related. This is a limitation of our research design and scale to date.

We confirmed that our general results are robust to the inclusion of the 193 MIT faculty from the seven departments under study who have separated from the Institute, retired, or passed away between 2000 and 2019. This population includes 51 faculty members from the three departments highlighted here, and 31 females overall. We identified 48 male founders and two female founders. Rates of BOD and SAB participation were similarly more skewed among this group than for current faculty.

6. Comparison of MIT's results with Stanford University's results
Of great interest is the similarity of our findings to those of Stanford University (Hanes, et al. 2018). As in the Stanford study, we found significant rates of commercialization by women faculty in some MIT engineering departments that contribute to the biotech start-up industry, but we also found a remarkable lack of participation by women faculty in basic biology departments, despite the fact that, in contrast to MIT, Stanford analyzed the biomedical-sciences departments in the School of Medicine as well as the Biology Department in the School of Humanities and Sciences. The Stanford study encompassed data from 2007-2014 and therefore did not capture changes over the past five years. Anecdotally, Professor Arvin, the senior author of this study, notes that more women biology faculty may be participating in commercialization activities at Stanford, a possibility we discuss further below.

Discussion and Conclusions
We examined participation by MIT women and men faculty members from three Science and four Engineering departments in the governance of science and technology start-up companies.

Our comparison across the seven departments highlighted the small number of women faculty in some departments and the variable rates of participation by women vs. men in different departments. To better understand this variability, we studied three departments in greater detail. We chose Biology, Biological Engineering (BE), and Chemical Engineering (CE), for two reasons: (1) The BBWG is particularly interested in biotech, and the faculty in these three departments have played an important role in the rise of this industry; (2) men and women faculty within each of these departments are similar in terms of career stage, and they work in similar-enough fields that neither differences in age or subfield should explain the variable rates of participation we see. (In several other departments, faculty work in diverse fields with potentially quite different commercialization rates.)

Two major conclusions, both consistent with published studies, emerge from our analysis of these three departments: (1) A marked underrepresentation of women faculty in Biology, per capita, relative to male colleagues, in founding start-ups and serving on their boards, and (2) similar rates of participation by women and men faculty along those dimensions, per capita, in Biological Engineering and Chemical Engineering. What could explain the difference?

Biological and Chemical Engineering: Much engineering research, even in academia, is focused on solving real-world problems, and founding companies is embedded in the engineering tradition. Studies have shown that most scientist-entrepreneurs are not "born" but "bred," and adapt to the expectations of their training and environment. Students and postdocs may learn a commercial orientation from mentors, and they may be inclined to engage with the commercial sector themselves when they become faculty, including women. The fact that these women engage in commercialization may provide a roadmap for how institutions may help an entrepreneurial microclimate develop in other arenas.

In the preceding and following articles, we address some hypotheses that have emerged from this finding and describe some interventional "experiments" that the BBWG has initiated.

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That said, we don't know whether the experiences and outcomes are identical for women and men faculty in Engineering – or in Science – who found companies. Unlike in Biology, the numbers of women in Engineering have been historically low, so even though the per-capita rates between men and women are similar, the overall company founding events are inevitably low, due to low numbers of women faculty.

Some women faculty have the perception that it is harder for them to raise capital than it is for male colleagues. National studies suggest that women are asked different questions when pitching investors, and data show that less than 3% of venture-capital dollars flow to women-founded companies. Other women faculty have had the perception that they are not invited to co-found companies with male colleagues when it might be appropriate to do so.

The first issue is discussed further below. The second is supported by our data for women in the three departments we studied in more detail: Of 26 MIT faculty in Biology, Chemical Engineering, and Biological Engineering who co-founded 27 companies with other MIT faculty, 26 of 26 co-founders were men.

Biology: The biotech industry grew out of scientific advances in the 1970s in molecular biology, a field without a tradition of commercialization. A number of early biotech companies were founded by businessmen who actively recruited university biology faculty, as in the well-known story of Genentech, the first U.S. biotech company. Genentech was founded in 1978 by UCSF's Herb Boyer, who was recruited by Bob Swanson, a graduate of MIT's Sloan School. Concerns that the commercialization of discoveries in molecular biology was not proceeding rapidly enough led to the passage in 1980 of the Bayh-Dole act. Bayh-Dole granted universities the ability to oversee the licensing of intellectual property arising from discoveries made by university faculty, trainees, and research staff through grants funded by taxpayer money to the universities. This change simplified the process of patenting and licensing – and, hence, commercialization.

Given these histories, the striking difference in commercialization rates by women vs. men faculty in Biology would seem to involve several questions: why women faculty were *not* recruited to found companies beginning in the 1970s-80s; why male faculty, once experienced themselves, did not bring women colleagues along; and why the difference in participation rates has persisted for so long. Any answer would require understanding why this gap has been seen at MIT, at Stanford, and at other leading research universities.

Extensive academic studies, and this report and Stanford's 2018 study, have eliminated a number of possible explanations for the entrepreneurial gender gap among faculty in biological sciences. We know it is: a) not primarily a pipeline problem, b) not because women lack academic qualifications compared to men, c) not because women are "too busy" compared to men, and d) not because women lack interest in entrepreneurial activities. A relative lack of experience in commercial engagement may play a significant role, but this is a Catch-22 situation that stems from women faculty members so rarely having participated in the first 40 years of the industry. Nationally, there is a trend to jumpstart board diversity by electing first-time women and minority board members without prior commercial experience. We expect that this type of approach will be necessary to accelerate progress.

Experts who have studied the entrepreneurial gap are still seeking an explanation, but divide the possibilities into factors affecting supply and factors affecting demand (Ding et al., 2012, Stephan and El-Ganainy, 2006.) Among the former, they have considered gender differences in attitudes to risk, competition, the "selling" and "promotion" of science, types of research, and geographic location; among the latter, they have explored the role of networks, the preferences of venture capitalists, and "gender discounting."

Our work through the BBWG has illuminated some of these possibilities, and in so doing has helped to shape the action plans outlined in the two accompanying articles. On the demand side, our meetings revealed frustration by VCs over the difficulty of identifying appropriate women faculty, particularly women with experience in the industry, as noted above. On the supply side, women faculty reported experiences that may help to explain their low rates of participation. These ranged from a woman faculty member in the 1970s being told that she could not participate because "businessmen don't work with women," to the present day when multiple women related nearly identical anecdotes about "pitching while female." One woman reported being warned before making a pitch not to take female trainees with her, and instead to take male students with her, so as to be taken more seriously. In terms of raising money, we learned that it can be preferable for a woman faculty member to have a male co-founder, because, as one woman told us, "women faculty are not heard – industry is far behind academia." Anecdotes about pitching while female are nearly identical from university to university, including at MIT, Stanford, and Johns Hopkins.

Conclusion: Discoveries in the labs of university faculty are not only the source of many biotech companies, but faculty train the next generation of scientists, some of whom will become entrepreneurs, so faculty participation has a particularly significant impact on the industry. Our results to date, and input from discussions among BBWG members, have helped to shape an action plan to close the entrepreneurial gender gap at the faculty level in the Boston biotech industry. Over time, the efforts of the Data Group should help to determine whether these plans have succeeded.

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Table 1. Rates of founding companies by current (June 2019) faculty in three departments of Science and four departments of Engineering.
Data sources: Faculty list provided by MIT Institutional Research, commercialization data obtained from public sources (see Methods).

		SCHOOL OF SCIENCE			SCHOOL OF ENGINEERING			
	TOTAL	BIOLOGY	BRAIN&COG	CHEMISTRY	BIO ENG	CHEM ENG	EECS	MATERIALS
Total # of current faculty (as of July 2019)	337	58	35	30	26	33	125	30
# of faculty who are female	73	14	12	6	5	5	22	9
% of faculty who are female	22%	24%	34%	20%	19%	15%	18%	30%
% of males who are full professor	70%	77%	65%	58%	76%	68%	72%	62%
% of females who are full professor	62%	71%	58%	50%	60%	60%	64%	56%
% of males who founded at least one company	40%	(19/44) 43%	(6/23) 26%	(6/24) 25%	(11/21) 52%	(10/28) 36%	(41/125) 40%	(12/21) 57%
% of females who founded at least one company	22%	(2/14) 14%	(1/12) 8%	(1/6) 17%	(3/5) 60%	(4/5) 80%	(4/22) 18%	(1/9) 11%

Table 2. Commercial-engagement activities by faculty in Biology, Biological Engineering, and Chemical Engineering.
Data sources: Faculty list for June 2019 provided by MIT Institutional Research; Commercialization activity obtained from public sources (see Methods).

	SCIENCE	ENGINEERING	
	BIOLOGY	BIO ENG	CHEM ENG**
Total # of current faculty (as of June 2019)	58	26	33
% of Faculty who are female	24%	19%	15%
# of SABs served on by male faculty	121	63	110 (43)
# of SABs served on by female faculty	9	5	9
# of BODs served on by male faculty	42	17	81 (23)
# of BODs served on by female faculty	1	2	4
# of company-founding events by male faculty*	63	25	71 (25)
# of company-founding events by female faculty	2	5	5
# of companies founded by male faculty	55	24	64 (18)
# of companies founded by female faculty	2	5	5

* Company founding event refers to an individual participating in founding a company. Due to co-founding these exceed the # of companies founded.
** This department includes one male faculty outlier. Data are shown both including and, in parentheses, excluding the outlier.

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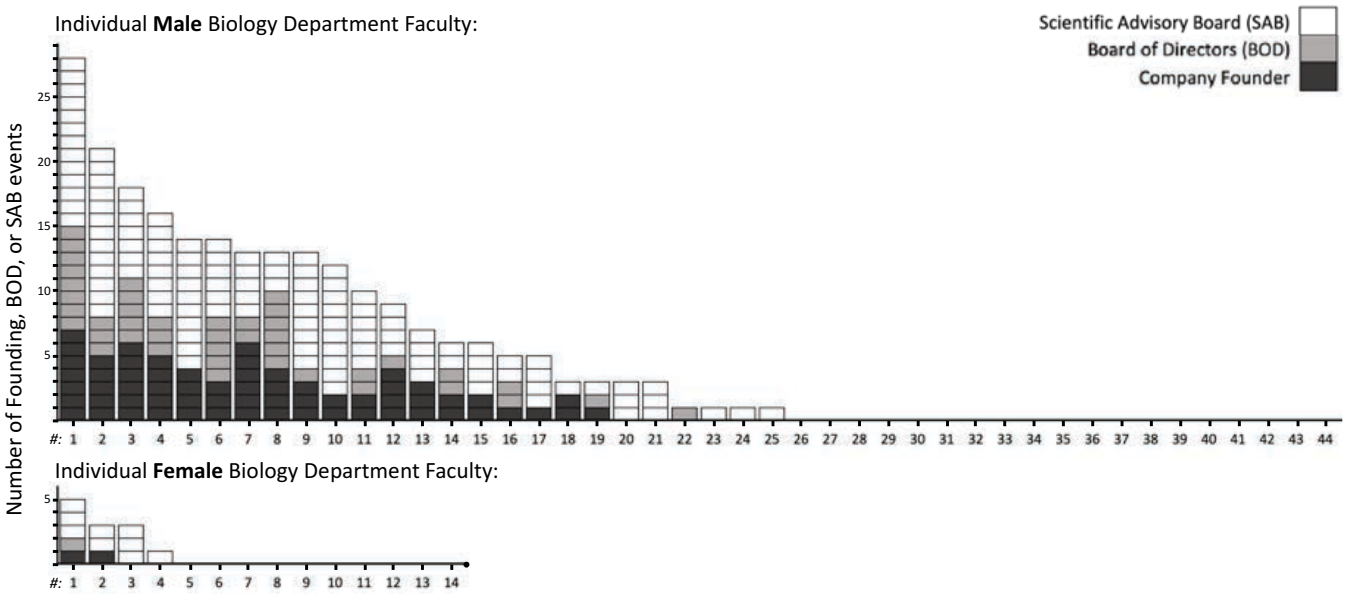
Figure 1. Commercial-engagement Activities by Individual Biology Department Faculty



Participation by women and men faculty in Biology as founders, and as BOD and SAB members of biotech start-ups and other science companies. The Biology Department at MIT has 58 faculty members, of whom 44 are male and 14 female (24%). Each vertical bar represents the commercialization activities of a single faculty member. A dark grey box represents a participation event as a founder of a company; a medium-colored grey box represents service on one BOD; and a white box represents service on one SAB. Male faculty participated in 63 company founding events and served on 42 BODs and 121 SABs. Of the male faculty, 19/44 (43%) are company founders. Female faculty participated in two company founding events and serve on one BOD and nine SABs. Of the female faculty, 2/14 (14%) are company founders. The number of companies founded by the male faculty is fewer than the total number of faculty company founding events because some faculty co-founded with other MIT faculty. In total, 57 companies were founded by current faculty in this department, 55 by men and two by women. This graph includes all current faculty members, of whom about 2/3 are tenured. While not studied in this report, an informal review of all faculty who have been in this department from the time the biotech industry began identified one additional woman and more than a dozen male faculty who founded biotech start-ups. (See Appendix.)

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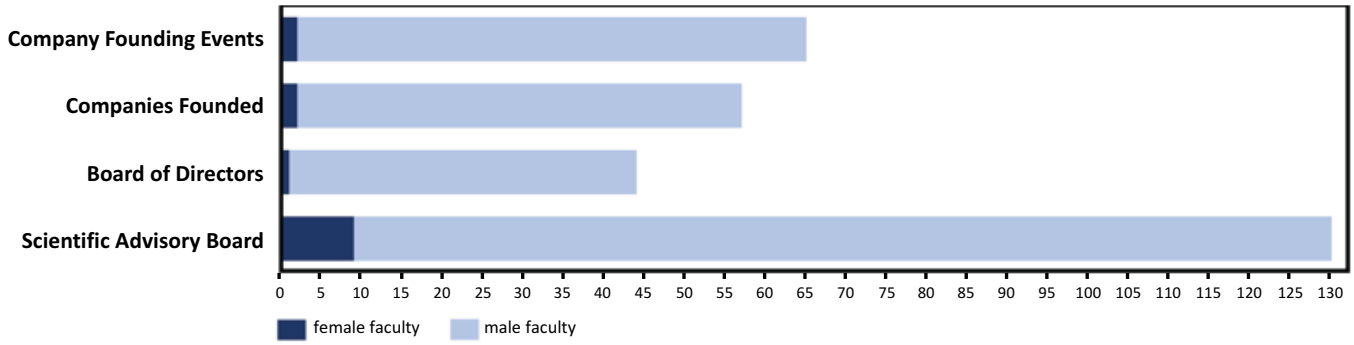
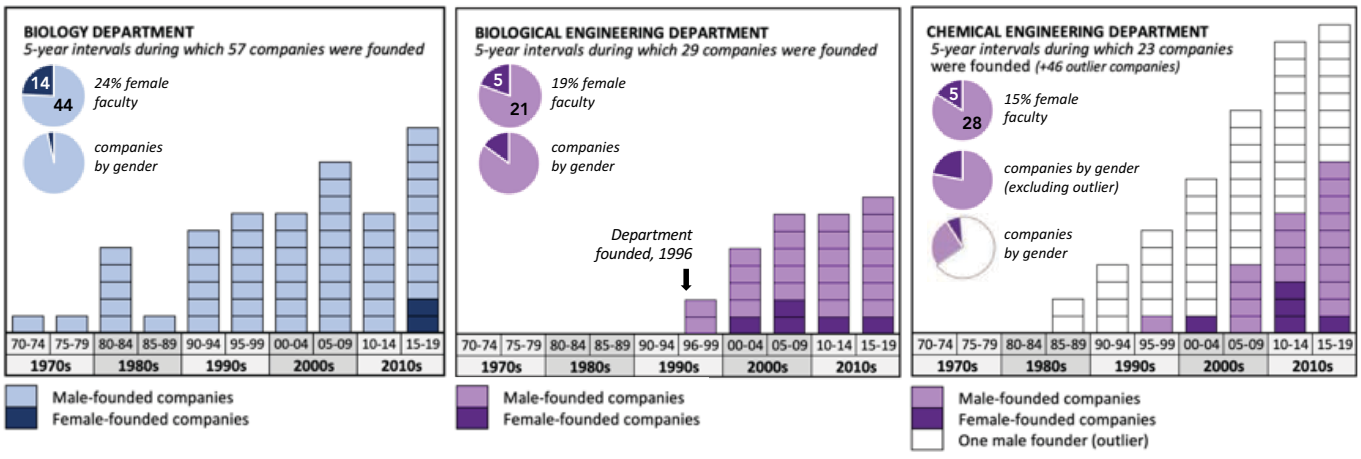
Figure 2. Summary of Commercial-engagement Activities by Male vs. Female Biology Department Faculty



Summary of the participation by women and men faculty in Biology as founders, and as BOD and SAB members of biotech start-ups and other science companies. The Biology Department has 58 faculty members, of whom 44 are male and 14 are female (24%). Women faculty's share of each type of event is represented by the dark portion of the bars, and men's by the light portion. The four types of events are founding a company (alone or with another MIT faculty) (65 events); the number of companies founded (57 companies); serving on a BOD (43 events total); and serving on an SAB (130 events total).

Figure 3. Five-year Time Intervals when Companies were Founded by Current (2019) Faculty in Biology, Biological Engineering, and Chemical Engineering



Five-year time intervals during which the companies were founded by faculty in the Biology, Biological Engineering, and Chemical Engineering Departments. Number of female and male faculty in each department is indicated in the top circle in each panel. Each dark blue or dark purple box represents a company founded by a female faculty member, each light blue or light purple box represents a company founded by a male faculty member. Each open box in the right-most panel represents a company founded by a single male faculty member, considered an outlier. In this article, data for this individual is noted but set aside if it distorts a particular conclusion. Note that the Biological Engineering Department was only founded in 1996; its timeline therefore only begins then, although we did study all historical founding, BOD, and SAB events for all current faculty as measurable in public data.

* We thank Heather Fleming for design and creation of the figures.

** We are deeply grateful to Dr. Elizabeth Boylan, Program Director at the Sloan Foundation, whose guidance and support were critical for this work.

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BBWG Data Group

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Methodological Appendix*

Dylan Nelson
Teresa Nelson

OUR PROJECT ENCOMPASSED FIVE OPERATIONAL phases between July 2019-August 2020. The overall design and management of the study was led by Dr. Teresa Nelson and the data collection team and the production of statistics and their representation was accomplished by Dylan Nelson. See Table A.1 for an overview of the data collection and analysis process.

As we collected and analyzed these data, we confronted a series of issues around sampling, source reliability, and variable definition. We've included our decisions in the Data Collection Best Practices Protocol to inform future data collection. Our goal was to uncover, for each faculty member, the number of companies that person founded with founding year and the number of BOD and SAB roles they assumed either for companies they founded, or otherwise.

A. Sampling and Coverage

The BBWG Chairs, Dr. Murray and Dr. Nelson, selected seven MIT departments for study based on the assessment that these were most focused on work related to biotechnology. The departments were: School of Science – Biology, Brain and Cognitive Science, and Chemistry; and School of Engineering – Electrical Engineering and Computer Science, Biological Engineering, Chemical Engineering, and Materials Science. Our study originally included the Physics Department, but this was removed after Phase I data collection showed low relative commercialization activity rates. The data identifying the faculty of these departments were obtained from the MIT Institutional Research department and included name with employment year, assigned department, sex, rank at hiring, and promotion timing. While the research as originally proposed presented a research design focused on biotechnology firms and their founders, we came to see quickly once the project got underway that departments were a better base for study. Faculty, over the course of their careers, move in their research across blurry industry boundaries while department assignments are generally reliable for faculty over time. This choice significantly expanded the number of faculty we studied, though we took it as the best solution to describe faculty governance in biotechnology.

Our focus on tenure-track, full-time, current (June 2019) MIT faculty meant we excluded multiple groups from our main analyses including visiting professors and lecturers as well as faculty who had left MIT, retired, or died. We believe this sampling choice strengthens the rhetorical heft of our work vis-a-vis corporate leaders and venture capitalists by highlighting current

Phase	Months (2019-20)	Summary	Operational Activities
1	July-August	Pilot Study	Systematizing data collection and operational approach, conducting a pilot study of data gathering and analysis, hiring one PhD student (Dylan), reporting to Sloan Foundation, meeting at MIT Innovation Initiative (MITii) to manage access to MIT Institutional Research (MIT-IR) data
2	September-December	Major Data Collection (on Faculty)	Hiring five UG students, refining search techniques for faculty and company data, narrowing key sources from over 30 to seven, managing undergraduate students weekly, reporting to the Sloan Foundation twice, preparing materials for December BBWG meeting
3	January-March	Major Data Collection (on Companies)	Hiring two PhD students, honing data collection on faculty-founded company major governance events, managing undergraduate students weekly, working with PIs for reporting to Sloan Foundation, preparing materials for BBWG meeting and MIT Faculty Newsletter, managing Covid-19 disruption
4	April-June	Analysis and Confirmation	Continued data collection and cleaning, managing undergraduate students weekly, analyses of the faculty and company data, developing best practices protocol along with undergraduates, conducting literature review for equity metrics, managing Covid-19 disruption, developing confirmatory analyses tests, testing for reliability
5	July-August	Final Report Preparation	Reviewing all data for quality to standards, confirmatory analyses, data collection report preparation, finalizing Protocol, finalizing equity metrics, writing the report including tables and figures

Table A.1

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*This Appendix, describing detailed methodology used by the BBWG Data Group, is taken from the final report to the Sloan Foundation, submitted August 15, 2020, for the project titled "Commercialization Activity of MIT faculty across Science and Engineering: Comparing the Engagement of Women and Men." Grant P2019-12358. It was written by Teresa Nelson, PhD, Project Research Director and Dylan Nelson, PhD candidate, University of Michigan, Data Scientist. Teresa Nelson is a gender scholar and professor of entrepreneurship specializing in high growth, venture baked companies. She is currently a Visiting Scholar for the NSF-funded ARC Network for gender equity in STEM, and Senior Director of Research and Policy for Astia, a venture capital firm for women-led businesses, as well as a Professor at Simmons.

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human capital resources. However, inspired by the career of a female Biology professor who had founded multiple companies before her 2016 death, we developed a confirmatory analysis to this work by observing the governance commercialization activity of all full-time tenure-track professors employed at MIT 2000-2018 for the sake of comparison. Results of that test are described in the confirmatory analysis section below.

The first primary data collection entailed collecting and recording data for 337 faculty members for founding and BOD/SAB membership in the years 1974-2019 (1974 was the earliest year of activity for any current faculty member). This scope also represented a broadening from our initial proposal which had taken 2000-2019 as its time focus. This change was made because the early days of the biotechnology industry and MIT faculty commercialization activity is an interwoven story.

The second major database we developed centered on all of the companies founded by these 337 faculty members. While we were able to reliably date company founding through corporate registration records, we found it difficult to accurately date BOD membership dates and SAB membership and dates of membership as many of these appointments lived outside of the digital record, particularly in the early years. We were most concerned with, and paid particular attention to, the threat of false negative bias regarding closed, older firms that would be least likely to have shared their data via the internet. To combat these concerns, we ran reliability tests outside of key data sources.

B. Data Source Selection and Reliability

To establish our data sources, we compiled a descriptive record of 35 publicly available data sources that could serve the project. These were drawn from categories such as general business (e.g., Pitchbook, Capital IQ), specialized business (e.g., Xconomy), business press (e.g., Factiva, *Wall Street Journal*, MIT news sources), general internet searches, company websites, books, and professional information sources (e.g., CVs, LinkedIn, MIT departmental websites). We then conducted a series of tests to reduce this array to seven key sources that were shown to provide supplemental information with integrity.

We analyzed the integrity and uniqueness of our datasets three times: during our pilot study, during our mid-project reflections, and at the end of our study. The overlap of information between our key sources was not highly patterned and so we retained the seven key sources throughout the study. As a general rule, we gave the most weight to statements faculty made about their own record, data on the MIT website, legally required data, other company sources, press sources, other sources. After the initial database was compiled, we conducted second level searches, meaning that for each identified role, other roles with the same company were confirmed or denied. Further, for each company founded, public records were sought to confirm faculty member governance activity. We estimate our number of individual searches as greater than 15,000, including reliability tests. We believe that our data exceeds the standard for academic publishing in terms of completeness and reliability.

C. Measuring Faculty Governance Commercialization

While many methodological issues can be managed through triangulation and validation, basic definitions provide the roadmap for the work on an ongoing basis. Throughout the study, we excluded nonprofit organizations, even if they offered a product for sale. We also excluded certain for-profit companies including consulting companies, venture capital companies, and non-science and technology related companies. We did include international companies where we found them, but we are not certain of our reach internationally because of the U.S. bias of our data sources. We made this decision in part because companies included were founded by female faculty, our segment of greatest interest. Also, because the companies sometimes blended U.S. and other nation status through their governance activities (e.g., founded in one country, IPO'd in another).

Another substantial measurement issue involved tracking down company name changes to avoid double counting. Name changes are common because many biotech firms, especially compared with other start-ups, adopt the name of their invented or most successful product initially, and then are persuaded to change upon growth, investment, or acquisition. Sometimes the distinction between a name change and the identification of a separate company is a judgement call. If counted twice, we required that a morphed second company be substantially different, as we would in the case of some spin-offs. This practically required doing a secondary test of all companies related to a specific faculty member after the initial database had been created, to confirm that these were, in fact, unique companies. Some databases, like CapitalIQ, were more useful for tracking the historical development of firms. Searching on Google for both names together was also useful.

D. Defining Faculty Characteristics and Governance Commercialization Activity

Membership on boards of directors was relatively straightforward to identify because of strong institutionalization – there is less ambiguity about what it means to serve as a director as it is a legal company classification and reporting is mandatory. There were, however, definitional and practical challenges in determining company founders, particularly for this set of companies.

In practice, firm founding is a socially constructed, not legally defined term (Nelson, 2010). The attribute of "founding" can be used to describe a range of levels and types of relationships occurring along a spectrum of activity from innovating the fundamentals to serving as an executive officer of the company that has transformed that innovation to a commercial product or service. This work gets ambiguous with science and technology compa-

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nies particularly when a faculty member is identified as a "scientific founder" (not a "founder") as they were responsible for the underlying discovery, or for supervising graduate students or postdocs who are themselves the actual innovators, but who are hands-off in terms of the discovery's development as a commercialization act. To operationalize this concept, we required a concrete report of founding from a key source taking company and faculty member self-identification as a "founder" as reliable evidence. We came to see that the more prolific faculty were in commercialization, the more likely they were to be mentioned as a "scientific advisor," perhaps due to legitimacy value.

Our third category of governance activity, SAB membership, was the most difficult to establish. Companies vary in having a scientific advisory board and in reporting its existence and membership publicly. SABs are not legally required, and public databases do not include the role reliably in their company reports. There is also a classification issue between "scientific advisors," often more informal and ad hoc in comparison to the more formal "scientific advisory board" and its members. We measured the latter requiring that at least one key source or secondary source list the faculty member in this role. We also coded "technical advisory board," a term more common for engineering related companies, or other similar names, as SABs. In conclusion, we are confident that the SAB role designations included in our database are accurate, and we expect that there are missing entries representing SAB role service that have not been officially announced.

E. Defining Company Characteristics and Major Governance Events

We faced three major conceptual issues in defining MIT faculty-founded company major governance events beyond those described in section C above (e.g., non-profit, non-scientific discovery, etc.). The first concerns company founding date. Because published year of founding can conflict across data sources due to varying founding "moments" such as company legal registration or invention patent filing dates, we used the first year that the company was registered in Delaware as our variable, since over 90% of companies register there. Where registration in another state (often Massachusetts or California) also existed, we confirmed that the Delaware date immediately preceded or repeated the other registration date, otherwise we sought secondary confirmation. For collecting data on founding date, the opencorporates.com website was useful.

Our second challenge in this category concerned providing some evidence regarding the scale and impact of the company founded. Did the company: 1) establish itself, 2) manage to share its innovation with the world, and 3) how profound was that impact? This research accomplishes point 1, provides evidence on point 2, and fails on point 3, except insofar as one can make the claim that companies that grow very large in their market reach have successfully done important work by touching market members widely and/or deeply. We envision a follow-on study that could investigate these data by science or technology base, versus departments. Such a study could also develop additional performance measures that would move closer to a true "impact" assessment.

By investigating how faculty founded companies established themselves within the entrepreneurship activity stream, through initial public offering (IPO), acquisition, closure, and/or venture capital investment, we provide evidence to use in answering these questions. The amount of venture capital investment can be taken in part as a measure of the market's belief in the innovation's ability to reach markets widely and/or deeply over time.

Note that these "company outcome" variables are not exclusive. Some faculty-founded companies went through an IPO but later went bankrupt, others were acquired and later went through IPO, etc. The process of collecting this data over time is tedious and requires expertise in entrepreneurial firm capital structure. We collected investment level data for each company across three leading data sources, then categorized the companies into reasonable VC investment ranges to smooth differences. We did not collect acquisition valuation data because this data is held closely by acquirers in most cases in the private market (Kaplan & Lerner, 2016).

For a handful of firms, it was hard to determine whether they were open or closed, as their current website revealed very little activity over the last two to five years (potentially "living death"), but we deferred where there was no concrete evidence of closure to call them still "open" as faculty life is very busy and projects may sit for some time. Ultimately, the closure status is "caught" as states, including Delaware and Massachusetts, will proceed with an involuntary revocation after not receiving required filings, which, without resolution, would prevent a company from continuing in business. In operationalizing closure, we included voluntary closure, bankruptcy, evidence of living death, or final asset sale, a case where remaining company assets are "acquired" in a way much different than a true acquisition of growth assets. The third major issue regarded the structuring of our database in terms of companies and faculty was the assigning of co-founded companies to departments. This was not an issue when both or all three co-founders were in the same MIT department. To manage this variable issue, we decided to code these firms as "cross-departmental." In terms of assigning companies a "sex of founder" variable, we chose to present the handful of companies founded by one female and one male in their own "cross-sex," rather than simply assigning these two firms to either binary sex category. We thought these collaborative categories were interesting as data points. We did not record non-MIT faculty co-founders in any way.

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The Future Founders Initiative: Q&A with Susan Hockfield and Sangeeta Bhatia

IN THE FALL OF 2018, THREE MIT FACULTY MEMBERS affiliated with the Koch Institute for Integrative Cancer Research – Sangeeta Bhatia (engineering), Susan Hockfield (president emerita), and Nancy Hopkins (biology emerita) – launched an initiative called the Boston Biotech Working Group (BBWG). The initiative cultivates women faculty as company founders and board members, activities in which they continue to lag behind their male counterparts. The idea drew inspiration from the pioneering study led by Hopkins and her colleagues in the 1990s on conditions faced by women faculty – including pay and lab-space inequities. The report appeared in the *MIT Faculty Newsletter* in March of 1999 and helped drive widespread changes, not just at MIT but at universities around the world.

The BBWG effort has grown tremendously and has given rise to the Future Founders Initiative at MIT. The two preceding articles in this special issue of the *Faculty Newsletter* are devoted to the effort. As is the following wide-ranging conversation, which Robert Buderi recently conducted virtually with Hockfield and Bhatia. Buderi, a member of the Future Founders Initiative, is also the former editor-in-chief of *Technology Review* and the founder of Xconomy. The conversation touched on a number of facets of the initiative and the changes it is fostering; a bootcamp series that is helping familiarize women faculty with entrepreneurship; a venture-capital upstart-fellowship program; a pledge by venture capitalists to significantly increase the number of women on boards of their companies; a new business-plan prize competition; and the possibility of scaling the effort to other regions.

Robert Buderi: Let's begin with how – and why – you both got involved in this effort. Sangeeta, in a way the story starts with you.

Sangeeta Bhatia: I have been a faculty member at MIT since 2005, and have been founding companies to accelerate delivering the benefits of our inventions to patients. When I got out into the ecosystem, I realized that I had very few peers that were doing the same – very few women faculty who were founders or board members, or who were pitching a group of VCs (Venture Capitalists) their ideas. I felt that acutely. As a woman in engineering, I've been underrepresented most of my career, but this world of entrepreneurship took underrepresentation to a whole new – incredibly low – level.

I've had the great fortune of having my long-time hero, Nancy Hopkins, as one of my office neighbors. Nancy and I started talking about the involvement of MIT faculty in the biotech boom in Cambridge, and the sense that women faculty were underrepresented relative to their representation on our faculty. I started to look into the data I could get at MIT through the Technology Licensing Office, and it aligned with our overall perception – but it also pointed to the possibility of departmental microclimates where more or fewer female-led startups were emerging.

Buderi: That's a great backdrop. Then things came to a head in September 2018, at an event in Boston[1] where Nancy Hopkins was being honored?

Bhatia: Yes. Nancy was given the annual Xconomy lifetime achievement award – a really important recognition in the biotech community. She spoke beautifully about the work that she'd done but also the work left to do. She explained, very bravely to an audience of largely biotech folks, that biotech today looks a lot like MIT did 40 years ago, that the industry has largely left women behind when it comes to company formation. Somehow Nancy's observations about the biotech industry just landed on us differently that night. We had heard the data before, but it came together in that moment as a call to action.

Susan Hockfield: Nancy and her women faculty colleagues are the heroes of these efforts to open opportunities to women in so many ways. I was at Yale in the 1990s, when the MIT Women in Science Report came out. I remember how stunning it was. Not stunning because it was a surprise; we all had a sense of the many inequities for women in science. But no one had ever said anything about it in that pointed a way, or done anything about it in as determined a way as MIT. The issues of salary and space equivalence between men and women became top of mind. The

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[1] This was the Xconomy Awards, an event put on by the media company founded by Buderi.

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impact of the MIT Report really was game-changing, not just at MIT but in academic institutions across the country. We still have a lot of work to do to level the playing field, but the universities of today are dramatically better places for women faculty than they were before the work by MIT women faculty in the 1990s.

MIT was well represented at the Xconomy awards that night to celebrate Nancy's impact. When Nancy then included her observations of the perpetuation of inequities at the interface of universities and company formation – where lab results translate into the marketplace – the ongoing opportunity gap for women just leapt into view. Her observations were a real wake-up call: it became clear that we in the greater Boston region had an opportunity to advance our regional advantage in this increasingly important and impactful world of biotech and biopharma. If we could include as many able and willing participants as possible – including our women scientists and engineers – in the entrepreneurship journey, we could expand the region's productivity dramatically. Nancy, Sangeeta, and I had a brainstorm together at that Xconomy dinner and said, "Let's do something. Let's figure out how we can change the game."

Bhatia: We understood that solving this problem required bringing a variety of stakeholders into the conversation. The American Academy of Arts and Sciences offered to host a series of dinner conversations. That was really how it started. We realized we needed all the pieces of the ecosystem in that conversation: venture capitalists, founders, academic administrators, media, and some folks from the foundation world, who we thought would be important to help support the work. The model for the conversation was self-assembly: we would bring people together, surface the critical pinch points, and then the participants would form working groups to catalyze change among relevant stakeholders for each impediment. Out of that came five working groups [Data, Venture Capital, Academic Deans, Innovation Ecosystem, and Founder Development].

Buderi: There were about 30 people at the first dinner in December 2018, as I recall.

Hockfield: Yes. We had an ultimate goal in mind, but we didn't have a pre-formed strategy to get to the goal. The strategy emerged step-by-step out of the dinner conversations. It happened organically, and very rapidly we developed an outline of what we needed to do. We started with only a general idea of the story, but we're from MIT, and only a sense of a story is insufficient. We needed to have data to demonstrate that the critical technology transfer path, of translating a discovery into a marketplace product, is not a level playing field.

Bhatia: The data allowed us to dispel a lot of myths. A very common myth is that representation of women in the pipeline is getting better with time, and therefore it is just a matter of time before women are included in every level of the ecosystem. We can now look at the data the team has generated and simply say, "That's not true." Women's participation really is not changing much over time. It allowed us to change the conversation and say, "We need new solutions. This isn't just about waiting and being optimistic."

Buderi: One of the most powerful things to come out of the data, described in the preceding article, was the idea that 40 or more companies might be missing because of the underrepresentation of MIT women faculty in company formation. Can you say more about how that concept came about?

Bhatia: That was Nancy's insight. One thing she taught us was that to really understand the data, you need to understand the institution and the players. It's actually really important to understand how companies get started from a faculty lab – filing an invention disclosure, raising capital, identifying co-founders. You have to understand that process to be able to look at the data and understand what it's telling you. That allowed us to ask: If these women, who are equally qualified, equally well-regarded, and have been here just as long, had been starting companies at a rate roughly equivalent to their male colleagues, what would have been the outcome? And that's how we got to the 40 missing companies. Simply put, if MIT's women faculty in the seven departments we analyzed had been founding companies at about the same rate as their male colleagues, there would be roughly 40 more companies founded – companies advancing new therapies, new diagnostics, new medical devices. Forty new ways to save or improve lives.

Hockfield: This feeds directly into the regional advantage argument – that by missing out on the possibility of more company formation, we're losing out on building a more robust innovation ecosystem in the region. The 40 missing companies is calculated only from the seven departments we've analyzed; the number across all of MIT is certainly even larger. This is a significant loss of potential; we're squandering valuable resources and talent, and we're defaulting on our responsibility to serve the world. And it raises another question: Why not explore every opportunity for new medicines, for new diagnostics, for new medical devices? We need them desperately.

What should be a source of real concern for greater Boston's biotech and biopharma enterprises is our history. We had the

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lead in digital technologies, but we lost it because we just didn't use our regional resources, our regional advantage, to their fullest potential. Losing our lead could happen again. We're not the only biotech hub. I don't view this simply as a matter of competition. To my mind, it's more importantly a question of responsibility.

Buderi: So the data, which is detailed in the preceding article, in a sense provided the hard facts that motivated the next steps from other workstreams. Can you give a rundown of what those next steps were – and where things stand now?

Bhatia: Harvey Lodish, [an MIT biology professor] who's a founder of Genzyme and Rubius, raised his hand and asked, "How can I help?" And so he and I decided to start a series we call the Future Founders Bootcamp, with support from Maria Zuber, the VP of Research, Anantha Chandrakasan, Dean of Engineering, and the whole MIT administration. We conceived of it pre-pandemic. We imagined that we would be convening women faculty for fireside chats with local founders to demystify the origin stories of companies. The silver lining of the pandemic, perhaps surprisingly, is that we were able to deliver our wish list of amazing founders from across the country – including Kathy High, who co-founded Spark Therapeutics in Philadelphia; and Carolyn Bertozzi at Stanford, who is a seven-time entrepreneur – and create highly personalized, curated conversations.

We touched on different financing strategies for starting a company. We talked with people who left the academy to run their companies, and others who pursued both tracks simultaneously and explored how they made those decisions. Now that we have 500 or so interested listeners, one of our goals is to qualify a cohort of participants who are interested in starting a company in the next one to three years and support them on their entrepreneurial journey. This would include one-on-one mentoring, networking, and a program that we're calling Dolphin Tank (a more friendly version of Shark Tank), in which participants get feedback on their ideas, and have the possibility of competing for a monetary prize to help start their company.

Buderi: I'd imagine there might be high interest in an incentive prize? How would it work?

Bhatia: The idea of incentive prizes, of course, is not new. It's something that MIT does very well – the 100K student entrepreneurship competition and the Climate Tech & Energy Prize are great examples. Anantha Chandrakasan, the dean of engineering, has championed the idea of a competition for women entrepreneurs with a visible and significant prize. We also want to offer small incentives, among them covering childcare costs to enable programmatic participation, and supporting travel expenses and other related costs as these women develop their ideas. If we are successful, then competition day will have a multiplier effect – all teams will gain exposure to the investor community and to one another. We hope to make a program announcement with an RFA later this year.

Buderi: Another working group was venture capital – which of course is often essential to getting a company off the ground. What has happened on that front?

Hockfield: One of the things that we all agreed on from the start, was that the existence of network effects is critically important when you want to move your ideas from your lab into the marketplace. The network effects are manifest in any number of steps along the way: how you raise money, how you put together your team, how you develop the expertise and understanding of how to take each step. While the conversations that build the necessary understanding seem to occur naturally among white male founders, women and minorities are not generally part of them. Our strategy is to "reverse engineer" these kinds of network effects for women who want to be company founders, or are curious about how to move down this path.

To start, they need to know where they can ask their questions. Activities like the bootcamp provide an opportunity for people to ask questions about how you get started and to meet people who can serve as their mentors. Another place where network effects are clearly important is in raising money. Among the members of our group were several venture capitalists from the Boston Venture Capital community. They quickly understood the problem and said, "We want to help change the game." Their workstream developed the idea of a pledge by venture capitalists to change the composition of their boards in a very short time. The target is within two years to have 25 percent women on the boards of companies where they have significant control. It's really encouraging that people who control so much of the deal flow are committed to changing the composition of the industry's participants, and that they're willing to step up to lead as change-makers.

Bhatia: The "VC Pledge" commitment is an important avenue to give women faculty deep insight into the process of company founding and development, as well as the personal connections to be able to recognize in their own work the possibility, and say, "Hey, I have a result in my lab that I think could be the next Biogen or Moderna."

Hockfield: On the VC side of company creation, there's another important exposure opportunity. Hanging out in a VC firm, where you can be part of the VC conversation as they review, vet, and fund new companies, is a terrific way to learn about what they do. To increase that kind of exposure, we are establishing a

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new program – the Accelerator Fellowships – that would give tenured women faculty the opportunity to spend some of their time in VC firms where they can be part of the action and actually see how it's done. We have great partners in our VC participants who are enthusiastic about hosting women faculty in their firms. We're currently aiming for an inaugural class of five Accelerator Fellows.

Bhatia: We plan to have an RFP supported by a bit of matchmaking. If you think about it from the VC perspective, they would host a colleague they let into their inner sanctum, who attends all the meetings where they're making big decisions. Conversely, faculty members need to give up precious time to go be around ideas that are not necessarily directly connected to their work. As a start, Pillar, Polaris Partners, and F-Prime have all offered to take on these fellows.

Hockfield: The program is designed to be extremely flexible. In consultation with the host firm, program participants can design their time to spend any number of days a week and some significant fraction of a semester (or a summer) in the program.

Buderi: The future founder initiative is focused on leveling the playing field for women; do you have plans to extend it to underrepresented minorities?

Bhatia: This study on women is just a beginning, a first step, and our initiative includes women of color, a key underrepresented group in the academy. However, the intersectionality of race and gender is undeniable in opportunities for entrepreneurship. A natural extension of our work will be to people of color. As we look at the small numbers of people of color on our faculty, it is important to acknowledge that there are even more foundational and deeper systemic racism issues to address. We need more tenured faculty members of color so that we can tackle the part of the pipeline this initiative covers – taking them from academia into the commercial sphere. We believe the framework we are putting in place for data tracking, inclusive networks and visible role models can be used to support inclusion of underrepresented groups overall, as well as in faculty start-ups. At this cultural moment of receptivity to the core issues of diversity and inclusion, we hope this study on women can serve as a catalyst to open up a larger conversation.

Buderi: These things you're talking about, they're all about building familiarity with the companyformation process and networks at the same time. It's all reinforcing.

What happens next? Are there any plans to take these ideas and programs beyond Boston – to a bigger scale?

Bhatia: Several foundations have expressed interest in our strategy. In some ways, our region is really special. Unfortunately, the underrepresentation of women in tech and biotech startups is not special. It's something you see over and over again, just about everywhere. We hope that if we're successful with the model we create in bringing women – and underrepresented minorities more broadly – into the network, we can make progress, quantify it, and disseminate the model to other innovation ecosystems. We've structured this Future Founders Initiative akin to a first chapter, a Future Founders Initiative at MIT. If we're successful in our own region, we hope to follow the pattern the 1999 Women in Science Report took, and send it out across the country and around the world.

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