

CAREER FEATURE

Opening doors for diverse talent in biotechnology with the BIO I-Corps experience

A new workshop brings together under-represented participants to gain experience working in diverse teams, identifying problems worth solving, and learning evidence-based entrepreneurship approaches.

The development of an effective drug or vaccine involves a series of complex interactions between academic researchers, industry experts and government regulators. It is now estimated to take 10 years, 300 full-time employees and nearly a billion dollars to bring a new therapeutic to the market¹. And while agricultural products, medical devices, health information systems or environmental sensors may not require the same level of resources, they share similar highly partnered, government-regulated commercialization pathways.

While the business press routinely covers serial entrepreneurs and companies that raise millions of dollars through financing and dealmaking², few academic researchers can turn to those same sources to read about what it takes to commercialize a research-based idea. In fact, many companies that garner press coverage eventually fail to put products on the market. As a result, most students, postdocs and professors rarely learn why promising ventures fail or how they might succeed^{3,4}. Compounding the problem, university-based researchers typically do not have the time, support systems⁵ or opportunities⁶ to immerse themselves in a product-development setting, leading to the majority of university research-based ideas facing a daunting ‘valley of death’ between basic research and commercialization. While pharma industry veterans² often cite a 90% failure rate in clinical studies, university-based ideas face great odds merely getting off campus, according to recent technology transfer analyses⁷⁻⁹.

That said, university-based ideas, discoveries and talented scientists, physicians and technologists are inarguably essential to the innovation ecosystem^{10,11}. Over the years business faculty^{4,12} and other university-based entrepreneurship programs¹³ have attempted to bridge the gap between basic academic research and viable commercial opportunities (or, in entrepreneurship jargon, “recognizing problems worth solving”). In parallel, campus-based innovation programs such as

the Massachusetts Institute of Technology’s Venture Mentoring Service and San Diego State University’s Zahn Innovation Center build mentor networks to help researchers map out commercialization strategies, connect with off-campus entrepreneurship networks and unmask behaviors needed to advance research-based innovation. However, the increase in university-driven entrepreneurial activity due to these efforts has been slow^{14,15}.

National Science Foundation Innovation Corps

This is the challenge addressed by the US National Science Foundation Innovation Corps (NSF I-Corps) program¹⁶. Aiming to create a larger pool of innovators capable of developing practical innovations based on federally funded research, I-Corps teams, paired with an industry mentor, learn entrepreneurial skills, test the feasibility of their ideas by interviewing experts and potential partners, and develop potential business models. NSF I-Corps courses are based on Blank’s emphasis on customer discovery¹⁷, Osterwalder’s business model canvas¹⁸ and Reis’s approach to iterative product development¹⁹. Nnakwe and co-workers¹⁶ report that from October 2011 to March 2017 over 970 teams from 222 universities in 46 states participated in the national I-Corps teams program. Subsequently, these teams founded over 320 companies and collectively raised more than \$83 million in follow-on funding. In 2015 the US National Institutes of Health also began offering I-Corps courses to Small Business Innovation Research (SBIR) phase 1 grantees.

I-Corps programs provide academic researchers with the tools to learn about biotech commercialization and develop an entrepreneurial mindset. I-Corps participants acquire the skills needed to build multidisciplinary teams, to focus on problems worth solving and to build a constellation of business experts, advisors and potential partners. Some I-Corps alumni directly apply these skills by starting new companies while others use

their skills as employees at established companies or other organizations in the bioentrepreneurship ecosystem.

Most I-Corps participants return to their university labs with an improved understanding of the experiments needed to de-risk their research ideas and smooth the path to licensing deals, venture support or commercialization. In addition, NSF data suggest that I-Corps graduates are also more likely to win research grants. This may be because I-Corps alumni are better able to recognize problems worth solving and to justify their research objectives to broad audiences.

The need for increased diversity in the bioentrepreneurial ecosystem

In 2016 NSF program directors noticed that the diversity of I-Corps participants did not reflect the diversity of the nation’s research enterprise. The NSF data mirrored observations made by many in the entrepreneurship ecosystem²⁰ and across the biotech industry as a whole. Baird points out that “less than 5% of startup investment goes to women, and less than 1% goes to African-Americans and Latinos,” and describes this ongoing lack of diversity as an “innovation blind spot,” limiting the places where companies form and grow, as well as the problems they choose to address²¹.

To meet the growing demand for highly trained professionals in the context of changing US demographics, companies need to recruit and retain employees from under-represented minority groups²². There is strong evidence that diverse teams are more innovative^{23,24}, as they are able to see a broader array of problems as well as potential solutions. Diverse teams add tremendous value and can maintain the creative edge required for sustained success of new and existing biotech companies.

Typically, early-career scientists and engineers become interested in the biotech industry through family or friends who work in the field. However, there are fewer women and members of under-represented minorities employed in biotech than in the general population, so these groups are less

likely to have personal connections in the industry. First-generation college students face the same disconnect. For example, before participating in California State University (CSU) I-Corps programs, over 70% of CSU applicants reported that they did not know anyone working in a biotech or biomedical company. Furthermore, a great number of academic researchers work in regions far from the biotech hubs of San Diego, San Francisco and Boston. This lack of exposure to biotech product development may lead under-represented researchers to eschew commercialization activities and biotech careers.

Over the past two decades, the United Negro College Fund (UNCF) has worked with biopharma companies to increase the number of African Americans pursuing careers in biomedical research and bioentrepreneurship. For example, the UNCF Merck Science Initiative and Fellowship Program was a 20-year partnership that funded over 700 undergraduate, graduate and postdoctoral fellows and exposed them to bioentrepreneurial pathways. More recently, the UNCF's Dr. Ernest E. Just Science Institute and Fellowship Program, supported by Bristol-Myers Squibb and the Genentech Foundation, has been promoting bioentrepreneurship among African Americans in the life sciences. This work accelerated when UNCF co-hosted a bioentrepreneurship and innovation symposium held in association with the 2016 Biotechnology Innovation Organization (BIO) convention in San Francisco.

Inspired by that event, we began working with UNCF to connect historically black colleges and universities with the NSF's I-Corps National Innovation Network (NIN). Concomitantly, NSF offered inclusive entrepreneurship supplemental grants to I-Corps sites and nodes to address the relative lack of diversity among I-Corps participants. In response, we sought support to design a bioentrepreneurship workshop for under-represented, early-career life science and bioengineering researchers working in academia.

Upon receiving NSF funding, we worked to develop a new workshop to broaden and deepen bioentrepreneurial opportunities for participants. We began by analyzing self-reported CSU I-Corps cohort experiences (<http://www.csuperb.org/csuicorps>). We recognized three common hurdles faced by all nascent academic bioentrepreneurs, but especially under-represented early-career researchers: ideation, team-building and self-doubt.

Ideation and implementation. Although they may be experts in their area of research, many academic faculty and students do not know how to connect their research programs to problems worth solving. Business school faculty call the process of creative thinking to identify entrepreneurial opportunities 'ideation' — a term that remains foreign to most academically trained scientists and engineers. The process of ideation taps into the collective brainpower of diverse teams to develop innovative solutions to important problems.

Most academic researchers lack awareness of intellectual property barriers to commercialization and potential markets that might support the time, effort and cost of commercializing research-based ideas. The ability to develop innovative ideas is further hampered on campuses that lack a culture of translational research or an emphasis on science, engineering, technology and math (STEM) research-based entrepreneurship. Campuses distant from biotech hubs, primarily undergraduate institutions and historically black colleges and universities, may lack the technology transfer expertise needed to evaluate or advance STEM invention disclosures. The combination of these factors makes it challenging for under-represented faculty and students to engage in the biotech ecosystem as entrepreneurs or employees.

Team-building and mentoring. Principal investigators and students alike report difficulty in forming the effective interdisciplinary teams needed to apply for I-Corps programs, as well as for company-building. Successful teams include members who are experts in different aspects of research, who are effective communicators, and who learn to understand the biotech commercialization ecosystem. The team must work well together with mutual respect, shared responsibilities, a sense of urgency and a common goal.

Building a supportive community is crucial for all bioentrepreneurs, but especially so for under-represented entrepreneurs aiming to win commercialization grants, land early rounds of financing or involve knowledgeable industry insiders. The importance of mentoring motivated the development of the NSF's NIN of mentors, instructors and teaching team members. I-Corps sites and nodes nationwide cooperate to pair industry professionals with I-Corps teams. Many mentor networks lack sufficient diversity, so we intentionally sought to include women and under-represented mentors who have

biotech product development experience. Interacting with successful mentors who come from diverse backgrounds is reassuring for under-represented students, who often lack biotech role models and industry connections.

Supportive training. Many entrepreneurial training programs operate on a 'shark tank' or 'boot camp' model that is off-putting to under-represented researchers, many of whom are already "fighting to overcome imposter syndrome and self-doubt."¹⁷ The experience of receiving harsh feedback, delivered by instructors or expert panels that lack diversity, can be especially alienating and discouraging for early-career researchers who do not see themselves represented by teaching team members and industry professionals in the room. Worse, expert panels and venture capitalists may not even recognize problems worth solving identified by under-represented entrepreneurs.¹⁹

Enhancing inclusion and diversity through a new BIO I-Corps workshop

We developed a new workshop to directly address and ameliorate specific challenges faced by diverse faculty and students interested in biotech entrepreneurship. Breaking with the team-driven I-Corps programming, we designed a three-day experiential workshop for individual researchers. Assistant professors, postdoctoral fellows, graduate students and undergraduates are eligible to participate. We work with partners at UNCF, the Annual Biomedical Research Conference for Minority Students, AUTM (formerly known as Association of University Technology Managers), the I-Corps NIN and VentureWell to recruit individual participants from campuses nationwide. For example, the 32 participants at the 2019 workshop represented 24 medical schools, colleges and universities. Last summer 49% of the participants were women, 35% self-reported as Black and 32% as Hispanic. Once participants arrive at the workshop, they are assigned to a four- or five-person team.

BIO I-Corps workshop participation is not gated or de-risked by having a prevalidated idea. Participants do not have commercialization experience, a developed venture concept, or intellectual property in hand. The workshop is not designed for researchers who are already moving down a commercialization pathway (that is, those who have filed a provisional patent application, licensed intellectual property, received SBIR funding, or so on). We point those applicants instead to

courses offered by I-Corps sites, nodes and incubators nationwide. As a result, the workshop opens up opportunities to experience the biotech ecosystem and gain commercialization insights previously perceived as out of reach or closed to under-represented, first-generation researchers and nascent entrepreneurs. We want participants to bring their own expertise, skills and perspectives to the workshop and to be open to sharing it and building on it as part of the ideation process.

We involve as many biotech industry insiders as possible by holding the workshop in parallel with BIO's annual convention. To date we have run bioentrepreneurship workshops at BIO 2017 in San Diego, BIO 2018 in Boston, BIO 2019 in Philadelphia and via videoconferencing at this year's BIO Digital 2020. BIO itself is a founding partner of the workshop and offers free exhibit hall registrations to all participants. The collaboration between BIO, state biotech industry associations, the I-Corps NIN and our workshop organizing committee ensures that we can colocate the workshop and recruit a diverse set of local industry experts and mentors as the convention moves around the country or is convened virtually. We embed supportive industry mentors with each team throughout the workshop. Mentors rotate so that teams get a chance to work with five or six different experts, hear different perspectives and expand professional networks.

Each workshop is a themed 'hackathon' focused on a broad topic of international interest, such as antimicrobial resistance or regenerative medicine. Industry experts kick off the workshop by describing unmet needs and high-level problems. Facilitators run exercises to teach ideation methods, interview tactics and evidence-based entrepreneurship concepts (Box 1). As a result, teams develop problem-solution fit hypotheses and formulate value propositions. Like all I-Corps teams nationwide, workshop teams then 'get out of the building' to test their ideas. In this case, they test hypotheses and assumptions on the convention's exhibition floor, a global gathering of representatives from over 1,800 companies and organizations. All workshop teams complete over 25 customer discovery interviews over the three-day workshop. The workshops feel like typical I-Corps courses, with all the pressures and demands of the real world. Upon completion of the workshop, participants become eligible for subsequent NSF I-Corps Teams grants (\$50,000) to advance their own research-based ideas.

Box 1 | BIO I-Corps workshop learning objectives

- Experience working in diverse teams to identify problems worth solving.
- Understand value proposition design.
- Apply evidence-based entrepreneurship concepts via customer discovery.
- Learn how to maximize efficiency in learning and networking in a conference setting.
- Learn about life sciences commercialization.

Workshop outcomes and impacts

The number of applicants to the BIO I-Corps workshop from across the nation confirms that early-career, under-represented researchers are interested in entrepreneurship opportunities and biotech commercialization. To date, we have worked with 80 participants from 49 universities in 26 states and Puerto Rico. Eighty-five percent reported that the experience exceeded expectations, 100% of the participants said that BIO is a good venue for learning and 100% reported they grew their professional network as a result of the workshop. Furthermore, 84% responded that they changed the way they approach research as a result of their BIO I-Corps

workshop experience. These self-reported gains in confidence and learning by BIO I-Corps workshop participants (Box 2) are comparable to gains reported by I-Corps teams participating in regional workshops and short courses nationwide.

While it may be too early to expect tangible outcomes, we followed up with 2017 and 2018 workshop participants to find out whether they took advantage of other I-Corps programs or progressed in biotech commercialization activity. Indeed, 64% report that they are continuing to learn about bioentrepreneurship or are working to advance a research-based venture concept by participating in I-Corps courses or joining regional or campus-based incubator programs. For example, after attending regional I-Corps courses, two 2017 workshop participants spun out or joined startup companies and subsequently won SBIR grants. Michael Conward, at the time a mechanical engineering graduate student at Rensselaer Polytechnic Institute, participated in the 2017 BIO I-Corps workshop and is now chief technology officer at SelfArray, an early-stage company based in Troy, New York. "BIO I-Corps led me to participate in a program at the New York City Regional Innovation Node," he says. "Originally, I had plans to start at Boeing after graduation.... Instead I work for a startup that is funded by an NSF SBIR phase 2 grant. I am the principal

Box 2 | Post-workshop participant reflections

- "One of the biggest mindset shifts was thinking that there is a big division between academia and 'big' tech/pharma. While resources, strategies and bottom lines might differ, the overarching desire to make the world a better and healthier place is refreshingly in alignment."
- "I was surprised to learn that there is an opportunity for anyone to start up a business, with the right mindset."
- "I think the sheer number of companies at BIO 2019 was really eye opening. I've been told that if you pursue a biology-oriented career, you'll only be able to work in a lab. This workshop proved that these limitations are not true and showed that there are a myriad of possibilities."
- "The most important aspect was that we were a group of 25 individuals from varying backgrounds, who were given a problem to solve, learning tools to approach the solution, and access to a variety of people as well as stakeholders. It was a truly insightful experience that we could come up with so many viable solutions in two days. It gave me confidence and opened my eyes and gave me wings to soar."
- "Attending the BIO convention was the greatest impact. Much of our learning is classroom-based, but there is no substitute for real-world experiential learning. I came away from the workshop with a much better understanding and appreciation of what the biotech industry is, how it operates at a high level and how different the types of questions and approaches are from basic science research."
- "The experience made me want to further my education in this area. I realized that the way I was going about research didn't really take into account the real world where it would potentially be used in or for people.... Sometimes it's easy to stay in a bubble of people in your field and lose sight of the whole picture."

investigator. BIO I-Corps introduced me to the entrepreneurship domain."

Our experience has shown there is an ongoing desire and need for bioentrepreneurship opportunities as well as supportive communities among under-represented early-career researchers. To build community and continuity, the teaching team invites workshop alumni back to mentor teams and, hopefully, to learn to run future BIO I-Corps workshops. One 2019 participant writes, "I am immensely proud to have been part of such a diverse group. For example, an observation I had was that in the workshop space, gender and ethnicity were sources of inclusion and empowerment, which is often not the case in academia and beyond. Lastly, it was affirming and sort of surprising to have such a cohesive teaching and mentoring team."

Conclusions

We developed the BIO I-Corps workshop in response to the need to increase inclusion and diversity in biotechnology among nascent academic entrepreneurs, innovative startup cofounders and creative employees at mature companies. The BIO I-Corps workshop brings together under-represented participants from across the United States to gain experience working in diverse teams, identifying problems worth solving, and learning evidence-based entrepreneurship approaches. The workshop has proven to be as successful as longer regional I-Corps courses, reflecting the impact of teamwork, embedded mentors and the intense, immersive experience of the annual BIO convention.

To scale up, we plan to grow the size and frequency of BIO I-Corps workshops with support from our partners and workshop alumni. In addition to the NSF's NIN, organizations ranging from the American Association for the Advancement of Science to the Society for Advancement of Chicanos/Hispanics and Native Americans in Science to the

Kauffman Foundation are also building inclusive entrepreneurial communities. There are opportunities ahead to better connect academic bioentrepreneurship efforts with global needs. Achieving this goal requires building an evolving, diverse base of expertise on which to teach biotech commercialization, connecting with current industry knowledge, improving campus technology transfer capabilities, and educating faculty and students so that they can advance their own entrepreneurial endeavors or find meaningful careers in the industry. These opportunities should not be reserved for industry insiders, the well connected or residents of biotech hubs. For the biotech ecosystem to continue to thrive and innovate, we need a diverse continuum of entrepreneurial-minded researchers and leaders who are comfortable and confident approaching problems worth solving. The BIO I-Corps workshop has proven to be a catalyst for increasing the inclusion of diverse researchers in bioentrepreneurship and the biotech industry. □

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Competing interests

The authors declare no competing interests.